DF109

GPS FOR DISASTER OPERATIONS

Instructor Guide

United States Fire Administration
Emergency Management Institute

Total Time: **150 minutes (2 hours 30 minutes) includes 40-minute activity.**
120 minutes (2 hours) – Summary version with activity

COURSE OBJECTIVES

Upon successfully completing this course, the participants will be able to:

• Explain basic GPS theory as applied to actual field use.

• Explain FEMA's use of coordinates.

• List common problems and their mitigation.

• Demonstrate the ability to configure the unit, obtain, record, and verify coordinates in the field.

RATIONALE

FEMA has identified a training requirement to provide all FEMA personnel who obtain, enter, or use geospatial coordinates with a basic understanding of the GPS system, units, and issues that effect accurate coordinates. FEMA uses geospatial information to fulfill several important agency requirements. Collection of erroneous coordinates has been identified as a major problem. This course is designed to provide the training to address these requirements.

COURSE GOAL

The purpose of this course is to educate FEMA staff about the proper use of GPS units and recording of coordinates.

TARGET AUDIENCE

The target audience for this course is as follows:

PRIMARY AUDIENCE	SECONDARY AUDIENCE
FEMA /State: FEMA staff who use GPS units FEMA staff who enter GPS coordinates FEMA staff who use or interpret coordinates	State/Local level applicants for public assistance

COURSE STRUCTURE/STRATEGY

All participants will be prepared for an environment of interactive lectures, class participation, demonstrations, and working independently or in groups to complete designed group activities. Participants will be encouraged to apply their existing program skills and knowledge as well as those newly acquired in challenging and dynamic scenarios.

Students will be required to demonstrate their acquisition of the skills and knowledge through a practical exercise conducted outside (or wherever it is possible to acquire satellites). Students will complete a practical exercise worksheet.

Two manuals are provides for the course; a Student Manual and an Instructor's Guide. The student materials are produced from printing the PowerPoint presentation handouts (three or six to a page). The student's should also be given the GPS job aid.

METHODOLGOY

The course requires both delivery in the classroom environment and outside. Since students are required to see screenshots from the units the class cannot be delivered solely outside unless teaching to less than three students. After introducing the unit, the instructor will give a brief overview of the history and use of GPS coordinates and mapping. Current problems with the collection of accurate coordinates will be presented. In order to give students a better appreciation of why they are asked to follow certain operational protocol, the basics of GPS theory and mapping are covered in section two. Section three covers the features found in a Garmin Etrex Vista that are applicable to the collection of coordinates. In addition, during this section the students will either confirm or configure their GPS unit to the FEMA standards. This section will utilize both lecture and demonstration, thus requiring the student to have a GPS unit in hand. Section four covers field operations and teaches the student steps required to standardize coordinate collection from a variety of damage sites. Scenarios are presented in pictures of actual damage sites that the class must determine the correct location to take a reading from. In section five the class moves outside in order to collect actual readings and conduct several exercises that demonstrate how the GPS unit works. In section six the students return to the classroom setting to verify that the readings they obtained are accurate when compared to either web-based mapping programs or software based basic mapping programs. Both lecture and a demonstration of either the Internet programs or software applications are presented. In the final section, seven, the objectives are summarized and key points reviewed.

COURSE DEPLOYMENT/DELIVERY

The course will be delivered as a one-day course to FEMA staff and other affected staff at a Disaster Field Office (DFO). The course material will be available through the DFTO.

DURATION

This course is designed for 2.5 student hours. This time includes lecture, breaks, and a practical exercise. A shorter version is also available which requires 2 student hours. This version spends 30 minutes less on the background behind mapping and how the GPS system works.

SCHEDULE

A sample agenda is provided to assist the instructor with preparation of the course.

Unit 1 Introduction	10 minutes	10 minutes
Unit 2 Mapping and Theory	30 minutes	05 minutes
Unit 3 Unit Features	20 minutes	20 minutes
Unit 4 Field Operations	20 minutes	20 minutes
Unit 5 Practical exercise	40 minutes	40 minutes
Unit 6 Quality Control	20 minutes	20 minutes
Unit 7 Summary	10 minutes	05 minutes
Total Time:	**2.5 hours**	**2 hours**

OVERVIEW OF COURSE UNITS AND EVALUATION

🕮 **Unit 1: Introduction** This section provides information about the history of the GPS system and how FEMA uses coordinate information.

🕮 **Unit 2: Mapping and GPS Theory** provides a basic overview of the role of maps, coordinates, and how the GPS unit determines its location. Emphasis is on those components that have field implications.

🕮 **Unit 3: Unit Features** provides information about the features of the Garmin Etrex Vista GPS units that are used in obtaining a correct set of coordinates.

🕮 **Unit 4: Field Operations** provide participants information about how to safely operate a GPS unit in the field. It also includes information on PA suggested practices on where to take a reading from.

🕮 **Unit 5: Practical Exercise** provides participants an opportunity to practice with the units in an outside environment. The students will complete a worksheet that has several exercises. The students will then work in small groups to obtain coordinates for simulated disaster sites.

🕮 **Unit 6: Quality Control** provides an overview of methods that can be used to verify coordinates relate to the actual position by using web-based mapping programs or programs that may be found at the DFO.

📖 **Unit 7: Summary** concludes the course and allows the instructor to review key points and ensure students understand the major steps in obtaining coordinates.

COURSE REFERENCES

The materials listed below are used in this course.

- *GPS for Disaster Operations, DF109,* Instructor Guide
- *GPS for Disaster Operations*, *DF109,* Student Manual (PowerPoint Handout)
- Course Handouts
  - Student Evaluation Forms (one set per group instructor)
  - GPS Coordinate Job Aid (brochure)
  - GPS Limits Excel Workbook
  - GPS Practical Exercise handout (page. 76)

SUPPORTING PUBLICATIONS

The following publications are useful to support the delivery of this course.

- *Public Assistance Program Geocoding Guidance for the Project Worksheet (PW) Memo*
- *Revised Global Positioning System (GPS) Equipment Specifications Memo*
- *NEMIS publication reference on entering coordinates*
- GARMIN *Etrex Vista Owner's Manual (www.garmin.com)*
- GARMIN *GPS Guide for beginner's (www.garmin.com/aboutGPS/manual.html)*
- GARMIN *An Introduction to Using a GARMIN GPS with paper maps. (www.garmin.com/aboutGPS/manual.html)*

SPACE REQUIREMENTS

The following space requirements are recommended:

- Primary Room for Instruction
  - Room Dimensions – for class of 25-30 students, minimum 25 ft. x 50 ft., or similar capacity

- Five to six tables, seating five to six people per table. Minimum table dimensions to accommodate students, instructors and course materials (manuals) 6 ft. x 8 ft.
- Classroom may also be setup as chairs setup in rows.
- Additional tables for additional materials and supplies, visual equipment (projector etc.), break foods (coffee, snacks)

- Outside Work area
  - An area outside (or able to receive strong satellite signals) must be scouted out prior to class. The area should be large enough to accommodate the class size with the students able to freely walk about. In most DFO settings this may be in the parking lot of landscaped area immediately adjoining the DFO. If the parking lot is busy confer with the safety officer to ensure a safe location is found for the practical exercise.

COURSE SUPPLIES AND EQUIPMENT

Audio-Visual/Electronic Equipment

- PowerPoint Software
- Computer and LCD Projector
- Overhead Projector and Screen (optional or as a backup)
- Hand-held microphones (two per class depending upon size of class)
- Lapel microphones for instructors (minimum of two depending upon size of class)
- Laser Pointer

Classroom Materials

- Tables/Chairs (see Space Requirements)
- Easel Pads and Stands (one for instructor)

Administrative Materials

- Class Roster
- Course Agenda
- Class Evaluation Form

Student Supplies

- Highlighters for participants (minimum one per student)
- Computer disk with course materials

INSTRUCTOR PREPARATION

- Download Instructional material from the DFTO website.
  - http://www.training.fema.gov/emiweb/dfto/stantrn.asp

- Make sure sufficient GPS units are available for students. Ideally, each student should have the GPS unit they are issued and will be using in the field. Obtaining units may require:
  - Making sure each student knows to bring their issued unit
  - Checking out units from APO for the class
  - Checking out units from PA for the class
  - Obtaining additional units from the DISC
  - Obtain additional AA batteries

- If obtaining GPS units that have not been turned on at the disaster site consider turning on units outside prior to class. This eliminates delays associated with cold startups and may help identify non-functional units.

- Determine the GPS unit configuration policy being used for the particular disaster. Depending upon the needs of the disaster the units may be configured by:
  - APO upon issuing the units
  - PA upon issuing the units
  - ESF 5, technical services, or GIS section after the unit is issued
  - By the student during the class.
  - Note: At this time the DISC does not configure the units

- Determine if any basic mapping programs are being loaded onto individual laptops. If so, be prepared to discuss how the software operates.

- Details for preparing for the practical exercise are covered in section five. The exercise must be conducted outside or in a location that it is possible to obtain satellite signals. If the class is being held outside, coordinate with the safety officer if the site poses any risk to the students. Coordination with security may also be required in order to allow the students to bring the units outside of the DFO.

COURSE EVALUATION

Level I: The Emergency Management Institute (EMI) Course Evaluation Form (FEMA 95-41) will be used to document student feedback on the overall evaluation of the quality of the content, the instruction and the facilities. The form uses a 1–5 rating system, with 5 being the highest. At the end of the course, the Course Manager will lead a feedback session so students also have the opportunity to provide verbal feedback on the course content.

Level II: A Student Evaluation will be performed to assess the students' ability to demonstrate their proficiency in applying the knowledge and skills needed. The Student Evaluation will be integrated into the practical exercise. The students will record GPS coordinates from a fixed location. These coordinates will be verified to ensure the student and the student's GPS unit is able to obtain accurate coordinates.

Overview

Overview
2 minutes

GPS for Disaster Field Operations

- Welcome students
- Introduce instructor(s)
- Introduce students. In the DFO setting this course may be part of several additional components of training. If the class is a standalone more time should be spent on making the students familiar with the classroom setting and instructors.
- Provide a general introduction to the course
- Obtain feedback on the classes level of expertise with GPS units by asking the following questions

- **How many have used GPS units before?**
- **How many have used a GARMIN Etrex or Vista?**
- **How many have configured a GPS unit?**
- **How many are aware of the PA memo on how GPS coordinates need to be collected?**

Notes:

Overview

Objectives

- Explain FEMA's use of coordinates.
- Explain basic GPS theory as applied to actual field use.
- List common problems and their mitigation.
- Demonstrate the ability to configure the unit, obtain, record, and verify coordinates in the field.

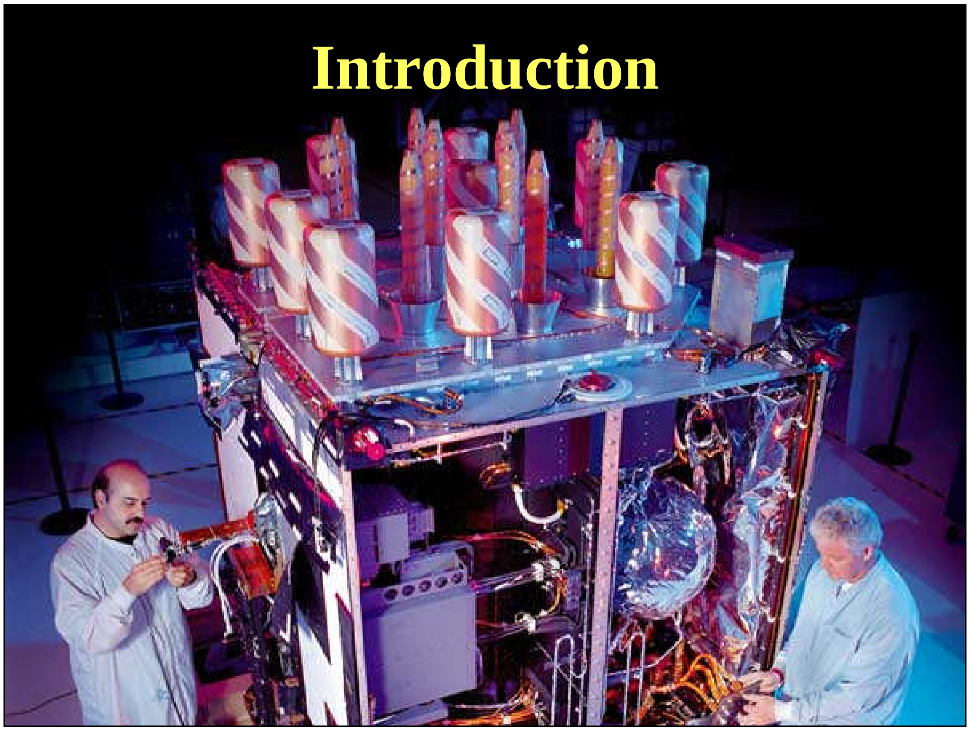
Objectives

- A GPS unit is a scientific instrument designed to collect geographic reference points known as coordinates. FEMA uses coordinates in many different ways. While a project officer initially collects the coordinates it's important to understand how this information gets used.
- In order to collect more accurate coordinates its important to understand some of the basic theory of maps and how the Global Positioning System or GPS works.
- Several different causes may lead to inaccurate coordinates, most of which are caused by human error and are preventable.
- In order to achieve the highest possible accuracy we will practice setting up the GPS units correctly and using them in the field.

Notes:

Who is responsible for configuration of the GPS unit will vary from disaster to disaster. The instructor should determine prior to the class if setup responsibility rests with the student, PA, ESF 5, GIS section, technical services, the APO, or another arrangement. Students still need to know how to check configuration.

Introduction

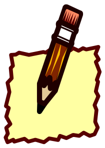


Introduction
10 minutes

Unit One - Introduction

- The course is divided into seven sections. In the introductory section we will discuss
  - Course content
  - How FEMA uses GPS coordinates
  - How well FEMA is currently collecting coordinates

Notes:



The photo illustrates the construction of a GPS satellite. New satellites weigh 4400 pounds and measure 5 x 6 x 6 feet. Each satellite is expected to last 10 years.

Introduction

Course Content

- Section 1 Introduction
- Section 2 Mapping and GPS Theory
- Section 3 Unit Features
- Section 4 Field Operations
- Section 5 Practical Exercise
- Section 6 Quality Control
- Section 7 Summary

Course Content

- The course is divided into seven sections
- Introduction- Provides an overview of GPS and how FEMA uses coordinates
- Mapping and GPS Theory- explains mapping and how GPS units obtain coordinates
- Features – discuss the basic features of a GARMIN Etrex Vista needed to get coordinates
- Field Operations – focuses on the protocol of how and where to collect coordinates
- Practical Exercise – Gives everyone the chance to practice with the GPS unit.
- Quality Control – goes over methods to verify the accuracy of coordinates. We will discuss both online and basic software programs.
- Summary – Reviews key points of the class.

Notes:

Introduction

Evolution of GPS

- 1978 NAVSTAR
- 1980 Civilian use
- 1995 Full Constellation
- 2000 Selective Availability turned off
- 2005 Additional Bands
- 2010 30-50 cm accuracy

Evolution of GPS

- In the early 70's the US military identified a need for more accurate navigation. US Air Force Space Command operates the system.
- In 1978 the first NAVSTAR (Navigation Satellite Time and Ranging) satellite was launched
- A degraded signal was made available for civilian use in 1980
- Mass Market applications became widespread once all 24 satellites were in position guaranteeing continuous coverage.
- In 2000 an executive order was signed turning off Selective Availability. This increased accuracy from 100 meters to 15 meters.
- Starting 2006 new satellites will be launched that further increase accuracy by increasing the power of the signal and the number of frequencies available.
- In addition the GPS system will work with the new European system (Galileo).
- These improvements will improve accuracy of the system to 30-50 cm for civilian users.

The GPS system is rapidly becoming more accurate and available to the general public. Most of the error in the future will be human error caused by not knowing how to use the information or GPS units.

Notes:

Introduction

FEMA use of GPS Information

- Often no physical address
- Federal Grants requirement
- Damage location validation
- Special considerations
- Flood Plain mapping
- Repetitive loss rule

FEMA's use of GPS Information

- FEMA currently uses the coordinates collected in several different ways
  - Providing a location, which is a federal grant requirement, when no physical address exists.
  - Help finding a damaged site after a repair has been made for verification and validation.
  - Determining if a site falls in a Special Flood Hazard Area.
  - Several uses by special consideration as discussed in the next slide.

- Repetitive Loss rule will require accurate plotting of the location. This was the driving issue in determining that coordinates needed to be accurate to 20 meters.

Notes:

Introduction

Who uses GPS information?

- Response – PDA
- Public Assistance – Project Worksheet, compliance
- Mitigation – site survey, flood plains
- Historic – Special maps (burial sites, districts)
- Environmental – Special maps (species, wetlands)
- GIS – special projects, creating maps
- Headquarters – long term tracking & analysis

FEMA Requires Accuracy of 20 Meters

Who uses GPS information?

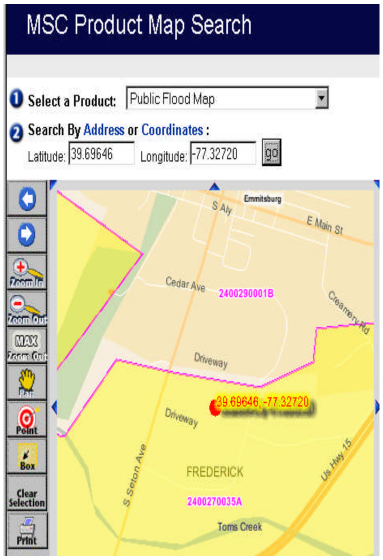
- Response – Hazard assessment, determine overall response.
- Public Assistance – Project Worksheet requirement, finding sites.
- Mitigation – Site surveys, determining if in floodplain.
- Historic – Several different maps to check against. Many don't have a street address such as burial sites and historic districts.
- Environmental – Check to see if site falls in endangered species area, wetlands, flood plains, etc.
- GIS – directly use the coordinates to conduct special projects and make maps.
- Headquarters – Long term tracking and analysis.

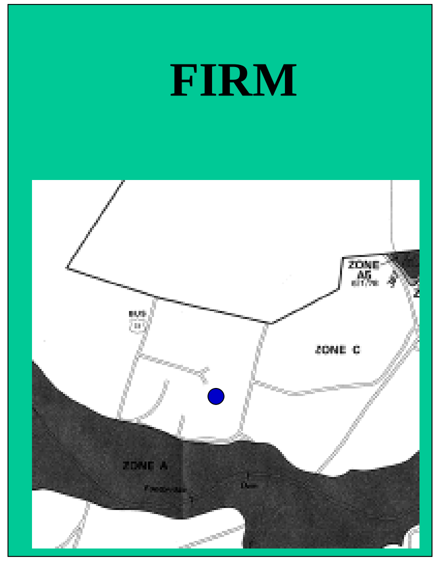
In order for the users of the coordinates to make proper decisions, the coordinates need to be accurate within 20 meters.

Notes:

Introduction

Example of Use





Example of Use

- By entering only the GPS coordinates into the FEMA map store search feature, you can bring up the specific flood map. This can make finding the specific FIRM a much easier task. This also allows a quick determination if a facility falls within a special hazard zone.

Notes:

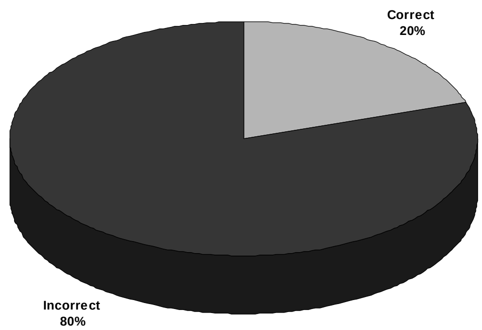
The URL of the FEMA map store is:

Store.msc.fema.gov

Introduction

Current FEMA Performance

- 20% PW correctly entered coordinates
- Common mistakes
  - Transcription errors
  - Wrongly formatted
  - Bad Conversions



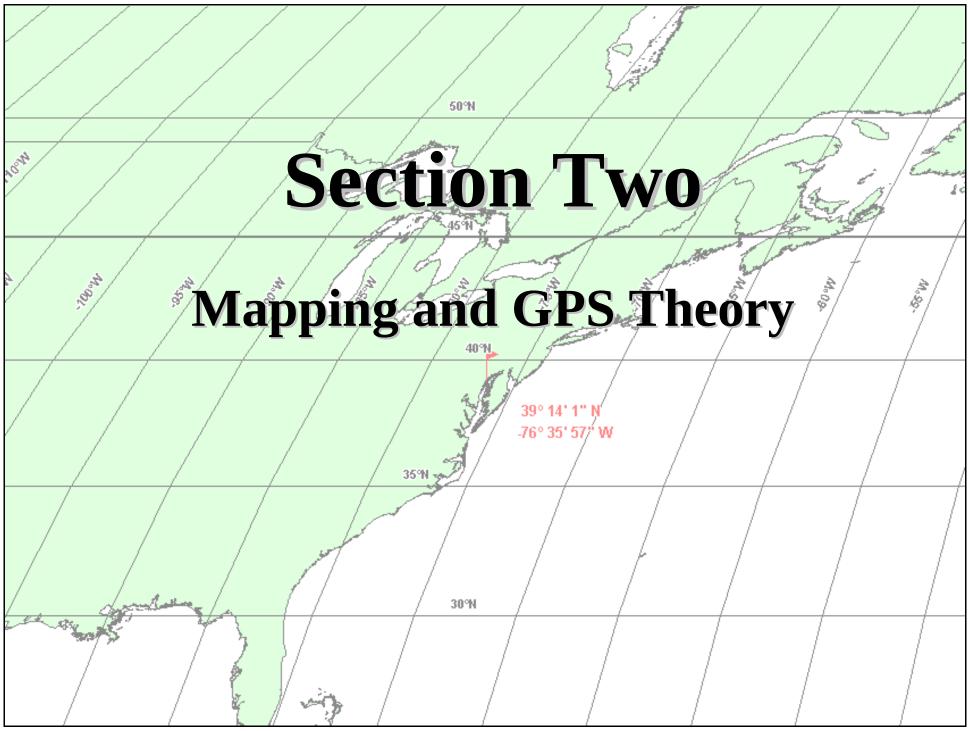
Target Performance Goal: 95% Correct

Current FEMA performance

- In 200X FEMA reviewed its performance of correctly entered coordinates on Project Worksheets. Coordinates were verified by GIS software to ensure they were accurate.
- It was found that only 20% of the coordinates were entered correctly.
- Common mistakes, which were caused by human error, included; failure to provide coordinates, transcription errors, wrongly configured GPS units, and improper conversion of coordinate formats.
- FEMA's goal and a major goal of this course is to make sure coordinates are entered correctly within 20 meters 95% of the time.

Notes:

Mapping and GPS Theory



Mapping & GPS Theory 30 minutes

Summary Version 5 minutes
Go to page 38-41

Mapping and GPS Theory

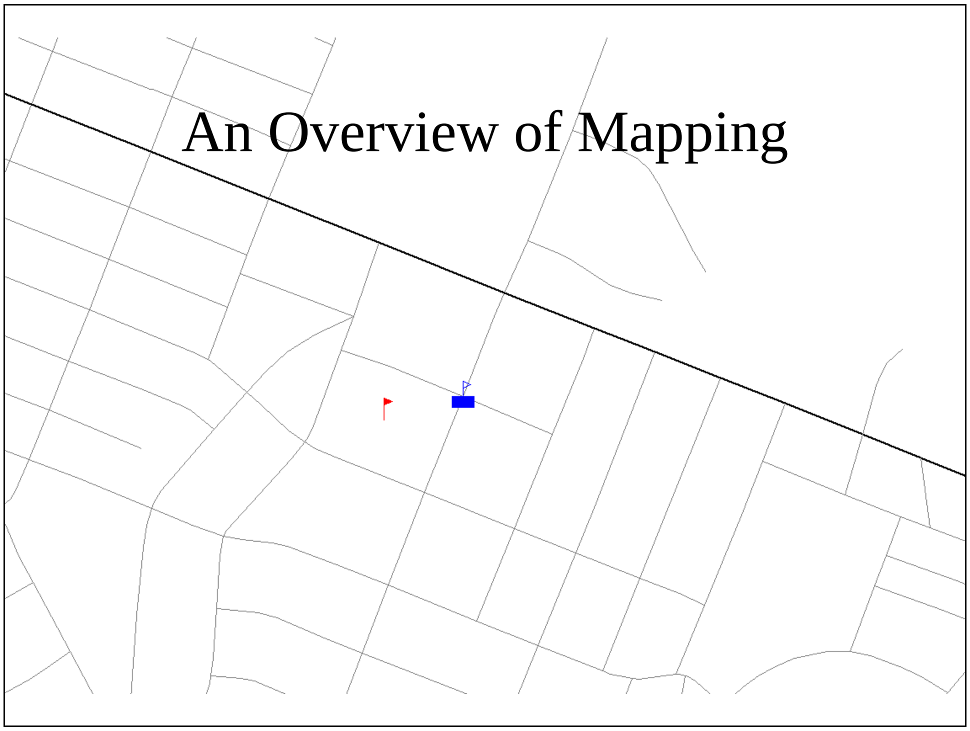
- The purpose of this section is to show the student how coordinates relate to maps, some basic information about maps, and how a GPS unit determines coordinates.
- It is important to understand the basics of how GPS works in order to obtain more accurate readings in the field. In addition, a basic understanding will assist the user determine where it may not be possible to obtain a GPS reading.

Notes:

Instructors are cautioned not to exceed the time allocated. The purpose is to provide an overview not an in-depth discussion of mapping and GPS systems.

Three summary slides (IG Page 38 - 41) exist at the end of this section. If the course must be shortened to meet time constraints these three slides may be shown to catch the major teaching points of section two.

Mapping and GPS Theory

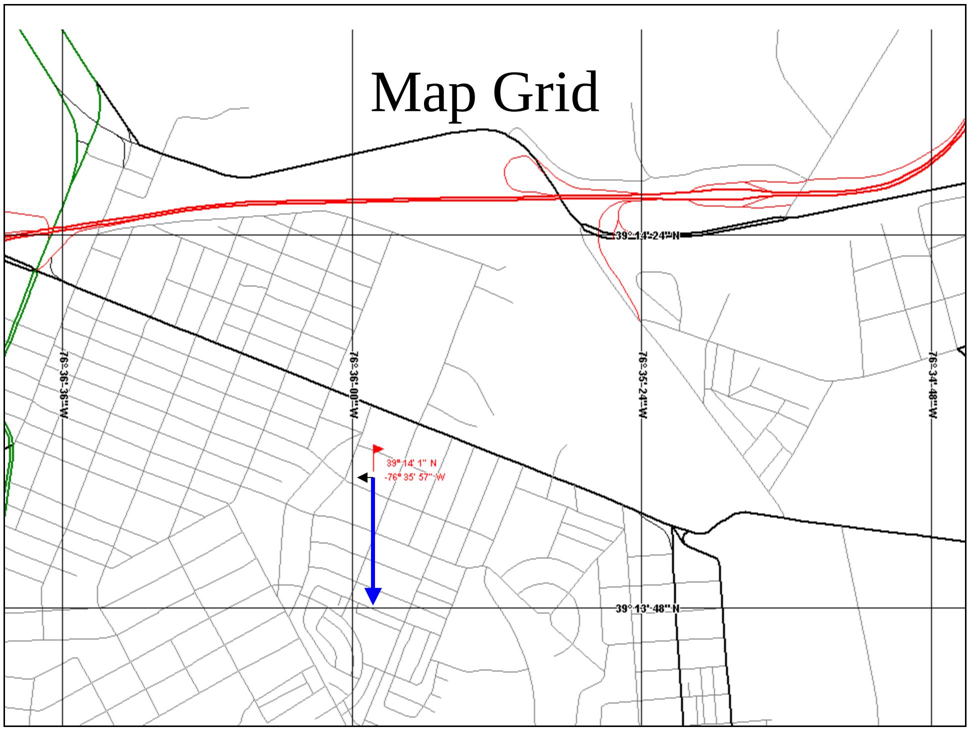


An Overview of Mapping

- A map is a two-dimensional representation of a three dimensional world. When depicting larger areas it also has the additional challenge of representing the surface of a sphere on to a flat piece of paper.
- A road map is the most familiar map for most of us. Common features of all maps include
  - Scale
  - Map orientation (usually the top of a map points to North)
  - Selectively only representing features that are of interest to the user
  - May or may not have a grid system laid over the map.
- Using a road map it is easy to locate an object that is at the intersection of two roads. Some road maps even give address numbers. Determining the location of the school represented in blue would be easy.
- However, it is difficult to give a location or find objects not on roads or near intersections.

Notes:

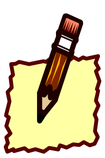
Mapping and GPS Theory



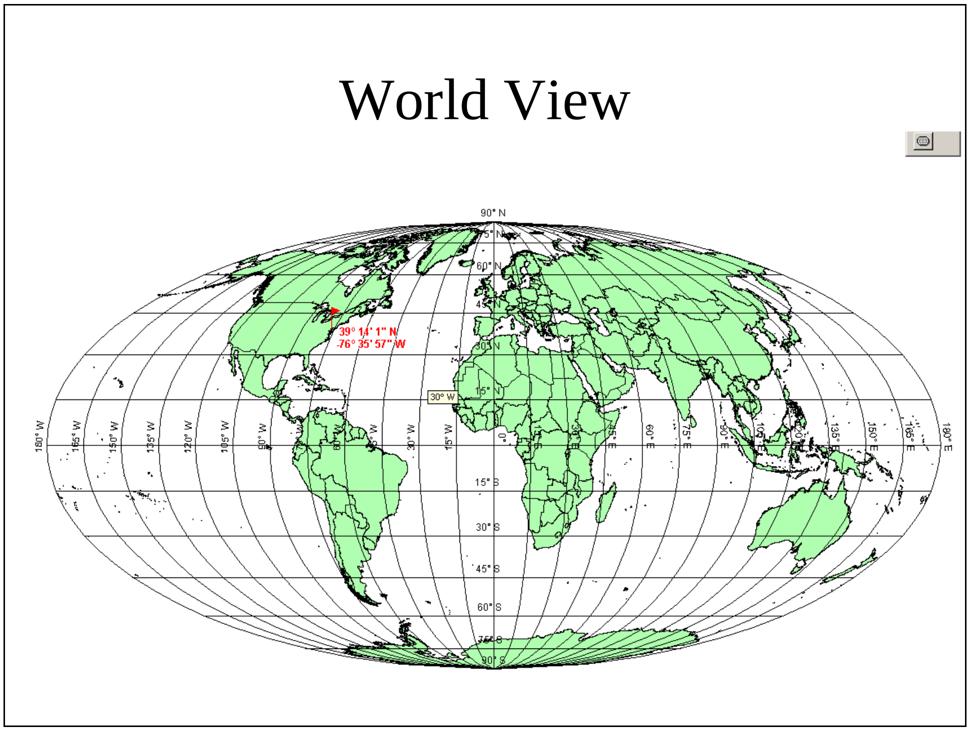
Map Grid

- Grids are placed on maps to make it easier to identify any point on the map.
- Many different types of grids exist. From simple letter number combinations used in many road maps to longer sets of numbers. Different grid systems start from different locations.
- To locate an object on the surface of the earth its location East to West and North to South needs to be given.
- In this example the site of interest is 39 degrees 14 minutes 1 second North of the Equator and 76 degrees 35 minutes 57 seconds East of the prime meridian using lines of latitude and longitude.

Notes:



Mapping and GPS Theory



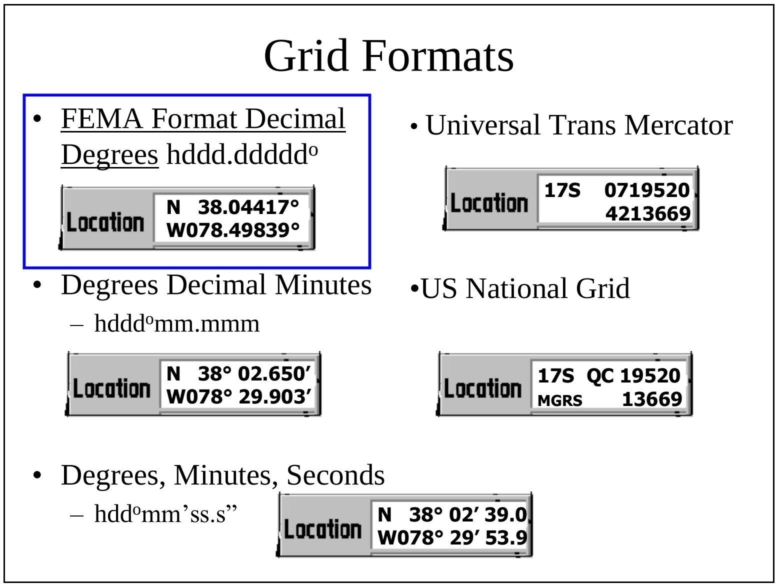
World View

- Latitude and Longitude is one of the oldest grid systems and can be used to give a precise location of any point on the earth.
- Lines of Latitude start at the equator and define your position north or South of the Equator up to the poles, which are 90°. Lines of latitude are parallel to each other.
- Lines of Longitude start at the prime meridian in Greenwich England (based upon England's naval supremacy at the time the majority of maps were made). Longitude is expressed as a negative number when measured east of the prime meridian and a positive number if west of the prime meridian. The International Date Line is found at 180° (east or west). Longitude gives your East-West location. Lines of Longitude vary in distance. They are wide at the equator and converge at the poles.

Notes:

A job aid (excel spreadsheet) is available that provides the possible ranges in latitude and longitude for each state and county.

Mapping and GPS Theory



Grid Formats

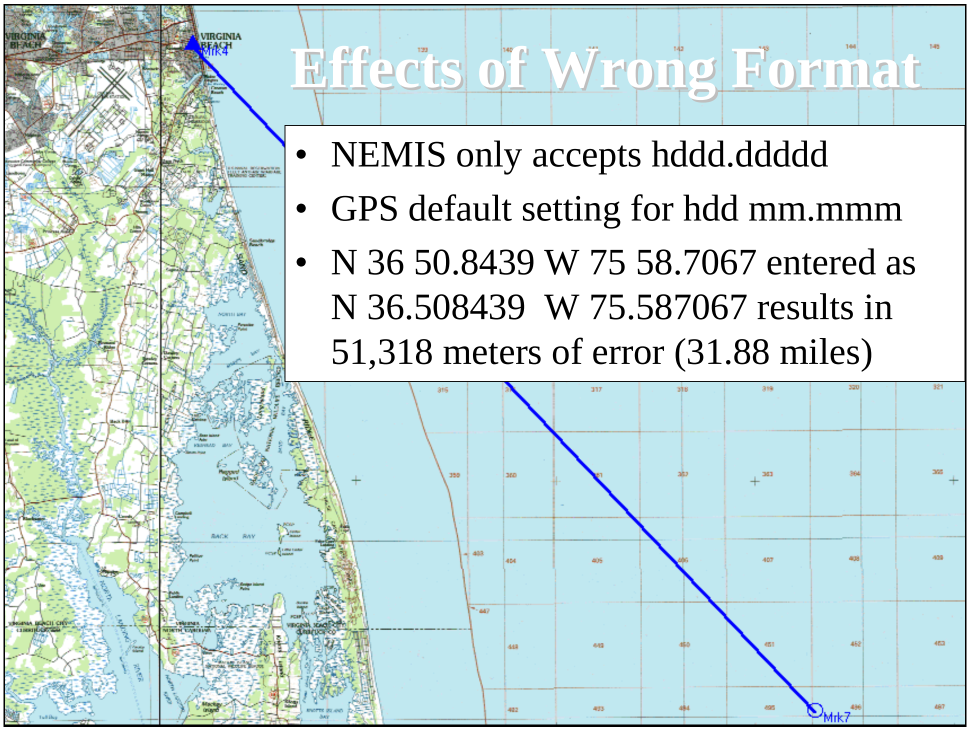
- Several different formats exist for giving coordinate positions. The two major formats are based upon latitude and longitude or a decimal based grid.
- NEMIS is currently configured to only accept latitude and longitude in the decimal degree format.
- This often causes confusion because the default configuration for the GPS unit is the degree decimal minute configuration. One minute of latitude equals a nautical mile, which is just slightly longer than a statue mile.
- Some people may also be familiar with the degree, minute, and second format. Where 60 seconds make a minute.
- Universal Transverse Mercator or UTM is a system based upon the metric system. North – South is measured in kilometers from the equator and East West is broken into zones.
- The US National Grid is derived from UTM but instead uses letter zones. It uses a two-letter combination and is also known as the Military Grid Reference System.

Emphasize how easy it is to confuse the FEMA decimal degree format with the GPS default of Degrees Decimal minutes.

Notes:

Coordinates are shown as they appear on the GPS unit and mark the same spot.

Mapping and GPS Theory



Effects of Wrong Format

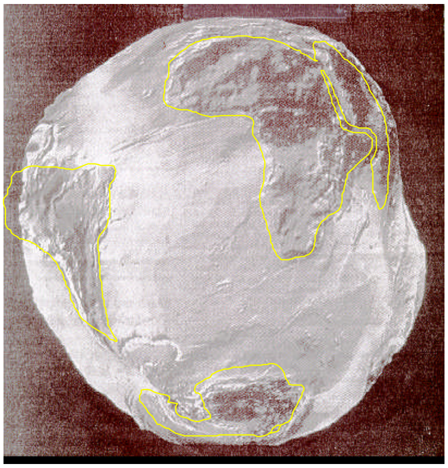
- One of the most common FEMA mistakes is caused by improper configuration of the GPS.
- The default setting of the GPS is Degrees decimal minutes.
- However, NEMIS only accepts Decimal Degrees.
- The difference in formats is detectable only by a space and the placement of the decimal point.
- In our example, the coordinates of the Virginia Beach municipal building were collected using the wrong format of Degrees Decimal minutes. It is possible to convert from Degrees Decimal minutes directly to Decimal Degrees. A tool is provided for conversions. The correct Decimal Degree coordinates are 36.8473988 –75.9784457.
- Unfortunately, the Degrees Decimal minutes were entered directly into NEMIS as a Decimal Degree coordinate. The incorrect coordinates falls into the Atlantic Ocean over 51 km or 32 miles away.

Emphasize we will discuss correctly configuring your GPS to avoid this mistake in section three. In addition if Degrees Decimal minutes is inadvertently collected a tool is provided to make corrections.

Mapping and GPS Theory

Datums- another user error

- Default setting is for NAD83 or WGS84
- NAD27 is older
- What is a datum
  - Start point for model
  - Mathematical model of earth – ellipsoid
  - World not round

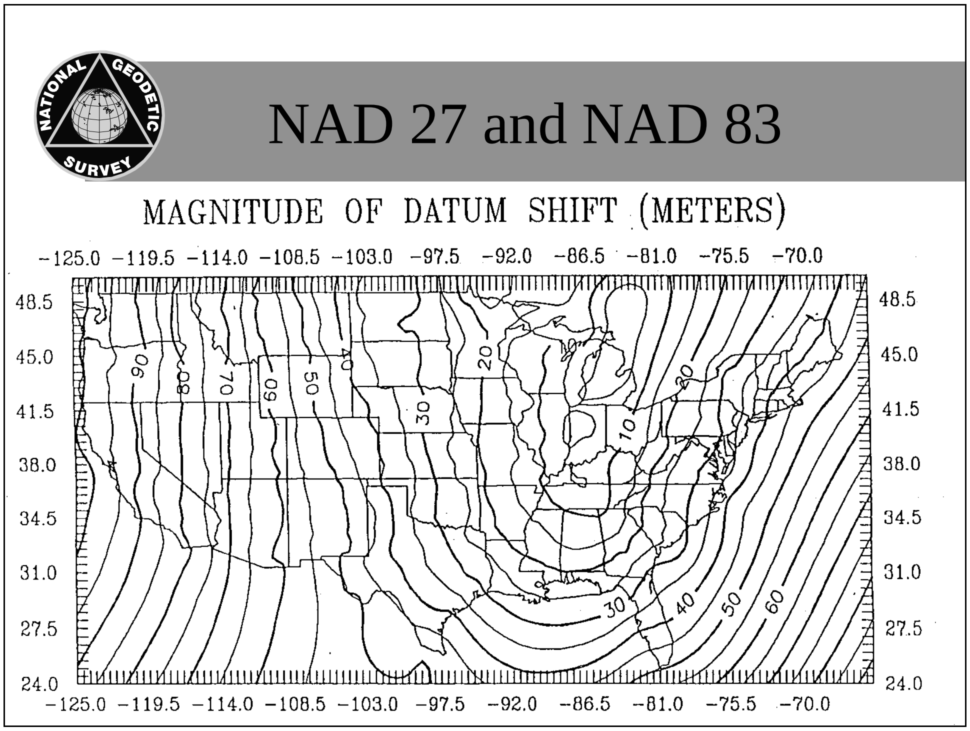


Datums – another user error

- Another source of configuration error is something called a datum.
- The default GPS datum is for WGS84 (World Geographic System) established in 1984. It is identical to a datum known as NAD83 (North American Datum of 1983). Both of these datums used the center of the earth as the starting point. They were conducted using laser survey instruments and verified later by GPS.
- Another common datum found on USGS topographic maps is NAD27 (North American Datum of 1927). This datum used Meades Ranch in Kansas as the starting point and was conducted using chains to work across the continent with many control points surveyed in the 1800’s.
- Datums are needed because all maps need a start point for a model. The earth must be modeled because it is not a perfect sphere. It bulges in the equator due to its orbit and is rather lumpy “potato” when viewed without water and clouds. The mathematical models accounts for the earth’s more ellipsoidal shape.

Notes:

Mapping and GPS Theory



NAD 27 vs. NAD 83

- The illustration shows the amount of error introduced if using NAD27 instead of WGS84/NAD83 as the datum.
- We will discuss how to configure the datum in section three.

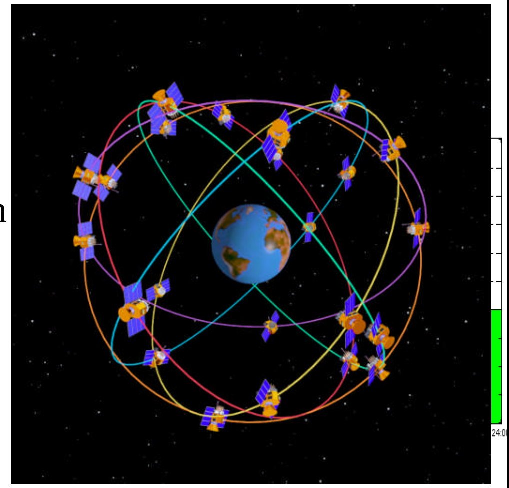
Emphasize that since FEMA's standard for accuracy is 20 meters, readings from most of the country will be inaccurate if the datum is not configured correctly.

Notes:

Mapping and GPS Theory

GPS – How does it Work?

- Constellation of 24 + satellites
- 6 different orbits
- 20,200 km above earth
- Able to see at least 4 at any given time



GPS – How does it work?

- Currently 29 satellites in 6 different orbital planes, with at least four satellites in each orbital plane. Arranged so that at least 4 satellites are always visible anywhere on earth. Number varies as new satellites are launched and old ones stop working.
- Placed in high orbit 20,200 km (12,000 miles) above earth to increase visibility and decrease effects of atmosphere on orbit.
- Satellites come in and out of visibility. Therefore, the number actually visible various from time to time.

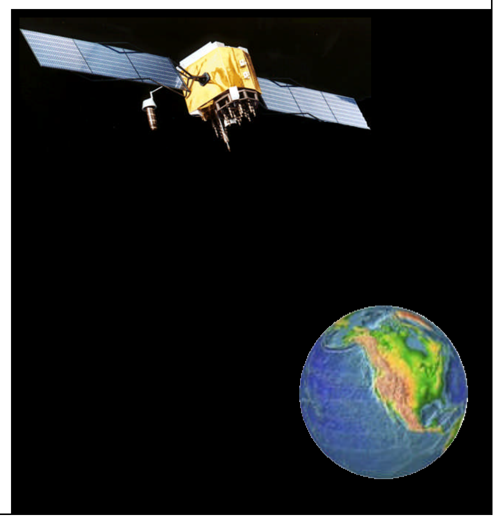
Notes:

Second click shows the number of satellites that were visible over Emmitsburg, MD, throughout a typical day. The number visible typically exceeds four. The current number of operational satellites can be obtained from www.tycho.usno.navy.mil/gpscurr.html

Mapping and Theory

The Signal from the Satellite

- Microwave Radio Frequency
- Effective Output 500W
- Line of Sight
- Pass through clouds, glass, plastic
- Blocked by buildings, mountains, etc.
- Weaker signals under trees



The Signal from the Satellite

- The satellite constantly transmits 500 watts at a civilian frequency of 1575.42 MHz.
- The signal travels line of sight and is able to pass through clouds, glass, and plastic.
- Buildings and mountains block the signal.
- The canopy of trees weakens the signal.
- A simple rule of thumb is: To see a satellite you need to see the sky.

Emphasize the simple rule of thumb: To see a satellite you need to see that portion of the sky.

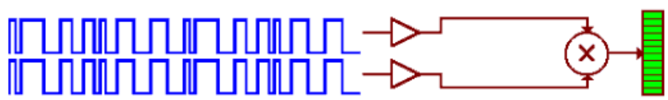
Notes:

Starting in 2006, new block F satellites will increase the effective output with a signal four times stronger.

Mapping and Theory

Signal Components

- Almanac (telemetry) updated location of all satellites
- Unique Satellite identification code
- Pseudorandom noise code – similar to a song
- Alignment of PRN code allows GPS receiver to determine time delay



Offset = 68.2 milliseconds

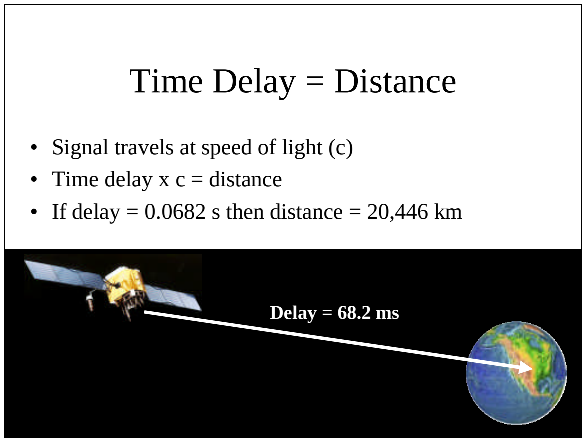
Signal Components

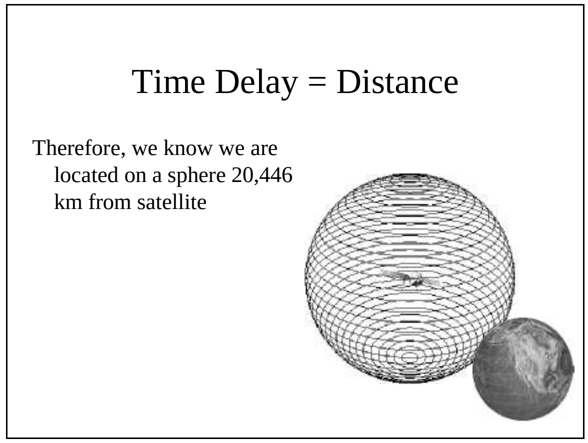
- The satellite transmits three types of information
  - The Almanac or precise orbit information for every GPS satellite is sent. A ground control station updates this information every 4-6 hours.
  - Each satellite sends out a unique identification called its PRN or Pseudorandom Noise Code. This allows the GPS unit to know which satellite the radio signal is coming from.
  - The PRN is a series of 0 and 1s that can be likened to a song. The GPS unit knows exactly when the song was sent. The GPS unit measures the offset of when the song is received from the satellite to determine the time delay. The offset is similar to determining the distance of a lightning strike by counting the seconds until the thunder is heard.

Notes:

Animated GIF demonstrates how the GPS unit compares the PRN received and the once expected to determine time offset.

Mapping and Theory





Time Delay = Distance

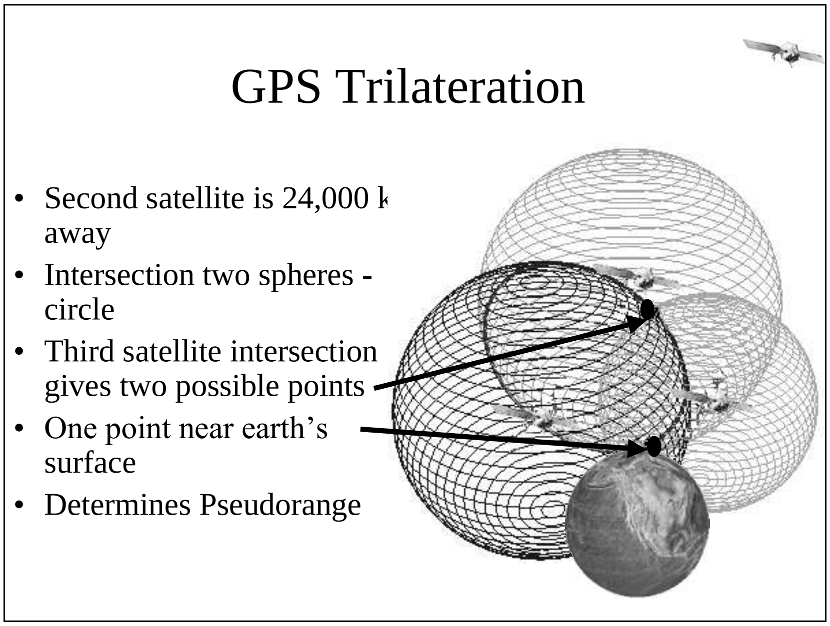
- The time delay can then be used to calculate the distance, since we know time multiplied by the speed of light equals distance.
- In our example a delay of 68.2 milliseconds equals 20,446 kilometers.

Second Slide

- This distance from the satellite defines a sphere that gives our possible locations.
- The exact location of the satellite is known from the downloaded telemetry or Almanac.

Notes:

Mapping and Theory



GPS “Trilateration”

- The process is called trilateration versus the more common term of triangulation. Triangulation involves angles and trilateration uses known distances from multiple reference points.
- If we acquire a second satellite and determine it is 24,000 km away we can draw a second sphere.
- The intersection of these two spheres makes a circle that represents our possible locations. This circle intersects with the surface of the earth is two locations.
- When we acquire a third satellite we can draw yet another sphere. It intersects in two unique points. One point is far away from the surface of the earth and moves rapidly, while the second point is at or near the earth’s surface and moves at a much smaller speed.
- The point near the earth’s surface is given as the coordinate
- If a fourth satellite is acquired then only one point of common intersection is possible.
- Pseudorange is a term given to the initial distance to each satellite. A final correction is made for minor differences in time, which will be explained in the next slide.

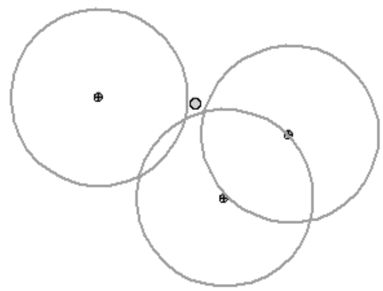
Notes:

Slide contains animation. First click adds third sphere. Second click adds arrow to excluded spot. Third and final click adds arrow to location on earth.

Mapping and Theory

Time Correction

- Error of 1/1000 second = 186 m
- Atomic Clocks used in Satellites
- Quartz Clock in GPS receiver
- Needs to be corrected
- Corrected by seeing fourth satellite



Time Correction

- Accurate time is critical to obtaining an accurate position.
- An error of one millisecond or 1/1000 of a second equals 186 meters.
- Onboard the GPS satellites are atomic clocks accurate to 10^{-15} seconds.
- However, the GPS unit only has a quartz clock accurate to only 10^{-6} seconds
- Therefore, the GPS unit must receive corrected time. This is done by receiving the signal from a fourth satellite and performing some simple algebraic equations.
- The illustrations demonstrate how the GPS unit determines the correct time.
  - (On screen) As previously discussed the distances of the three satellites should intersect at one discrete point near the earth's surface.
  - (First-click) However, if the GPS unit clock is running too fast the ranges will overlap.
  - (Second-click) If the GPS unit clock is running too slow the ranges will not touch
  - (Third-click) Therefore, the GPS solves the equation to adjust the clock so that the ranges will give a precise intersection.

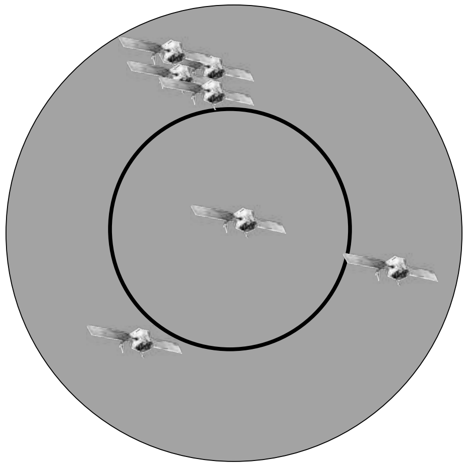
Emphasize in order to fix a location four satellites are required.

Notes:

Mapping and Theory

More Satellites are Better

- Receiver selects best signal
- Geometry affects accuracy
- Watch satellite page
- If accruing signal from additional satellites good to wait
- Able to watch accuracy improve



More Satellites are better

- Generally, the more satellites present the more accurate the coordinate.
- This relates to the overall geometry of the satellites.
- The more spread out over the sky the better the reading.
- Unfortunately, satellites near the horizon are more difficult to acquire when standing on the ground. High-end GPS units often exclude satellites within 10° of the horizon.
- GPS unit has a sky chart on the same page the coordinates are displayed.
- The sky chart can be used to check the geometry.
- It is worthwhile to wait to acquire additional satellites because accuracy dramatically improves. Initial illustration shows poor geometry. The second click shows ideal geometry of one satellite directly overhead with three others evenly spaced about the horizon.

Notes:

The sky chart will be covered in more detail later. The initial illustration shows poor geometry (which is measured by PDOP- Positional Dilution of Precision). The second mouse click shows better geometry with additional satellites.

Mapping and Theory

Sources of Error

Error Source	Typical Error	DGPS Error
Selective Availability*	100 M	-
Ionosphere	10 M	-
Troposphere	1 M	-
SV Clock	1 M	-
SV Orbit	1 M	-
Pseudo – Range Noise	1 M	1 M
Receiver Noise	1 M	1 M
Multipath	0.5 M	0.5 M
TOTAL ERROR	**15 M**	**3 M**

Sources of Error

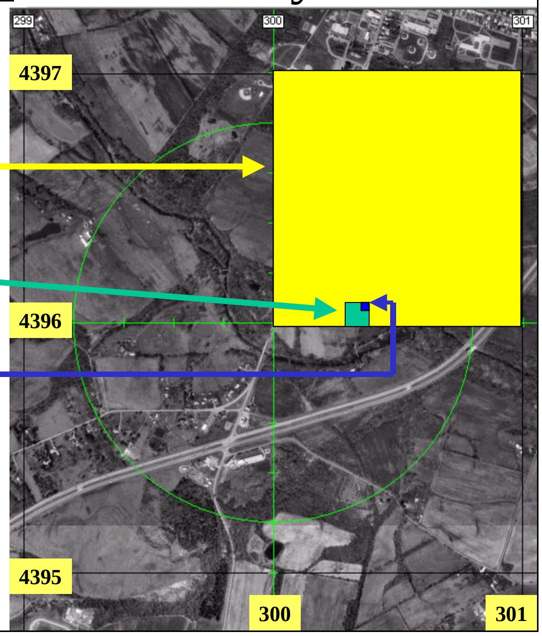
- The following chart summarizes all of the errors caused by the GPS system. Many of these errors can be corrected by using differential GPS (DGPS), which we will discuss later. All of these errors will be further magnified by poor satellite geometry.
- Prior to turning off selective availability in 2000 this was clearly the largest source of error.
- Bubbling within the ionosphere and troposphere, which delays the radio signal now causes the largest source of error. GPS becomes less accurate during solar flares and in the late evening due to the effects of "space weather".
- Errors caused by the satellite include minor drifts in the atomic clocks and departures from the predicted orbits.
- Errors caused by the GPS units include minor errors in the offset delay of the PRN code and receiver noise.
- Multipath error is caused by the radio signal reflecting off mountains or buildings and taking slightly longer to reach the GPS unit.
- The overall accuracy of the GPS system is now 15 meters.
- Differential correction is able to correct for all the sources of error except for those caused by the GPS unit and multipath error and improves accuracy to 3 meters.

Emphasize GPS system errors are within the FEMA standard of accuracy of 20 meters. An explanation of dGPS will shortly follow.

Mapping and Theory

Precision vs Accuracy

- 0300,4396 defines a 1000 meter box
- 03003,43960 defines a 100 meter box
- 030039,439609 defines a 10 meter box
- 0300391,4396091 gives a 1 meter box
- Garmin Etrex gives 1 meter precision



Precision vs. Accuracy

- The number of digits you record from the GPS define the precision of the coordinates.
- As an extra pair of digits is added to the coordinates the area defined becomes more precise.
- The displayed precision of the Garmin Etrex is one meter.
- This defines a unique address on the surface of the earth that is one meter by one meter in size. The addition of one more set of digits would make the precision define an area of 10 centimeters by 10 centimeters. This may become possible for consumer GPS units by 2010.

Notes:

The one-meter precision is for UTM and USNG, which were used in the example since it is decimal based. The amount of precision for latitude and longitude will vary depending upon ones latitude. For most of the Continental US the last digit defines about 1.1 meters (3.6 feet). Aerial photograph is of EMI.

Mapping and Theory

Precision vs Accuracy

- Unit precise to 1 meter

  BUT

- Accurate to 100 meter when selective availability turned on
- Accurate to 15 m under normal conditions
- Accurate to 3 m if WAAS signal obtained

Precision vs. Accuracy

- While the GPS unit may give a coordinate precise to a one-meter square, several factors will cause the coordinate given to be inaccurate to a certain degree.
- Prior to 2000 when selective availability was turned on the units were only accurate to 100 meters. This means 95% of the time the coordinates would have fallen in the red circle.
- GPS is now normally accurate to 15 meters (yellow circle).
- With differential correction, the system and atmospheric errors cancel out and the accuracy improves to 3 meters (green circle).

Notes:

Mapping and Theory

dGPS - WAAS

- dGPS able to reduce several errors (<3m accuracy)
- Receiver able to pick up dGPS signal called WAAS
- WAAS explanation

DGPS - WAAS

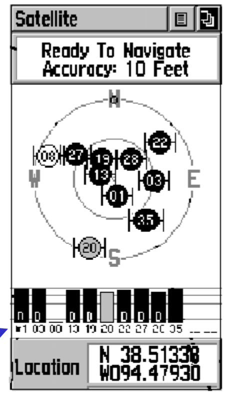
- The Garmin Etrex is able to pick up the differential GPS signal produced by the FAA called WAAS or Wide Area Augmentation System. The system was designed to allow aircraft to land using GPS.
- Ground stations throughout North America receive GPS coordinates. Since the stations' positions are known to within millimeters they record the difference between their actual position and what GPS says.
- These correction factors are then communicated to a ground station, which sends a correction factor back up to two satellites in geosynchronous orbit over the Atlantic and Pacific Ocean. The further north and the further away from the US Coasts, the more difficult to lock-on to the geosynchronous satellites.
- If you are able to lock-on to the Geo satellite then a differential correction is automatically loaded into your GPS unit.

Notes:

Mapping and Theory

Can you tell if you have dGPS?

- Newer versions of GPS units are WAAS enabled
- Garmin Etrex series indicates differential data downloaded by a “D” on Satellite page.
- Accuracy improves



Satellite Page with 9 Satellites Being Tracked and WAAS Enabled. WAAS Satellite is No. 35 and 'D' in Signal Bars for GPS Satellites

Can you tell if you have dGPS?

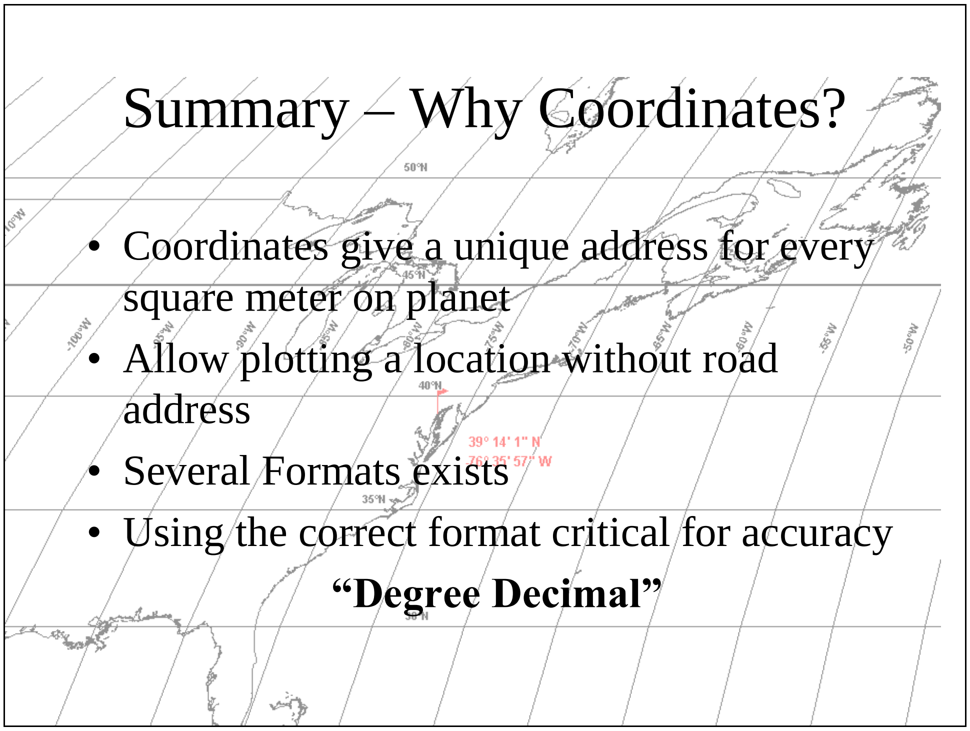
- The Garmin Etrex units are all able to obtain a WAAS signal.
- However, the default configuration is set to turn this feature off.
- If you are in the Midwest – East coast you can tell you locked onto the WAAS satellite if you get a signal from satellite number 35. Shortly thereafter, you will see a D appear in the signal bar when the differential information for that satellite has been downloaded. You should also observe the accuracy improve.
- On the West coast the WAAS satellite over the Pacific is no 47.
- The WAAS satellites are scheduled to be switched from over the ocean to over the continental United States in order to improve reception.

Notes:

Locking onto the WAAS signal can take considerable time, especially after moving to a new location. It may take up to 15 minutes or more.

Mapping and Theory

Summary Version 5 minutes



Summary – Why Coordinates

- The GPS unit is used to determine a set of coordinates for a unique location. They are capable of giving a unique location or address to every square meter (or less) on the planet.
- Coordinates can give a location anywhere, including where roads don't exist.
- Several different formats exist. FEMA uses the format most common for input into GIS software, which is the Degrees Decimal Format. The degrees refer to lines of latitude and longitude, which can be seen in the background of the slide.

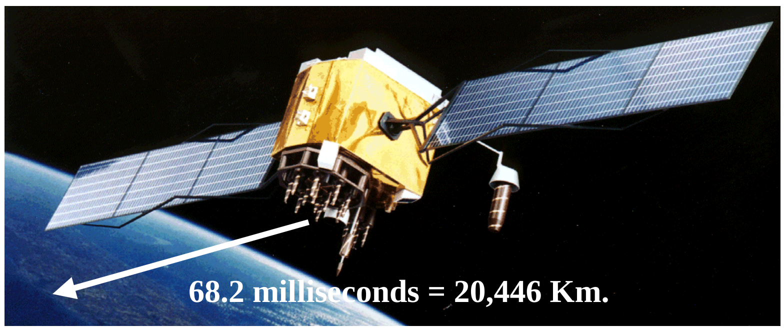
Notes:

The amount of time spent on the summary will vary depending upon whether it is used to summarize the section or if it is used as a replacement for section two. If used as a replacement it should be given at least 5 minutes. Materials and information from previous slides can be used to augment the presentation.

Mapping and Theory

Summary – How GPS Works

- Obtain radio signal from GPS satellite
- Measures time it takes for signal to reach earth to determine distance
- With four satellites can determine location



Summary – How GPS Works

- The GPS unit receives a radio signal from the GPS satellite located in high orbit. This radio signal is line of sight and can be blocked by substantial structures or mountains.
- The GPS unit measures how long it takes the signal from the satellite reach it and are then able to calculate the distance.
- Once signals from 4 Satellites are obtained the GPS unit is able to perform several calculations in order to give a coordinate.

Notes:

Mapping and Theory

Summary – Improving Accuracy

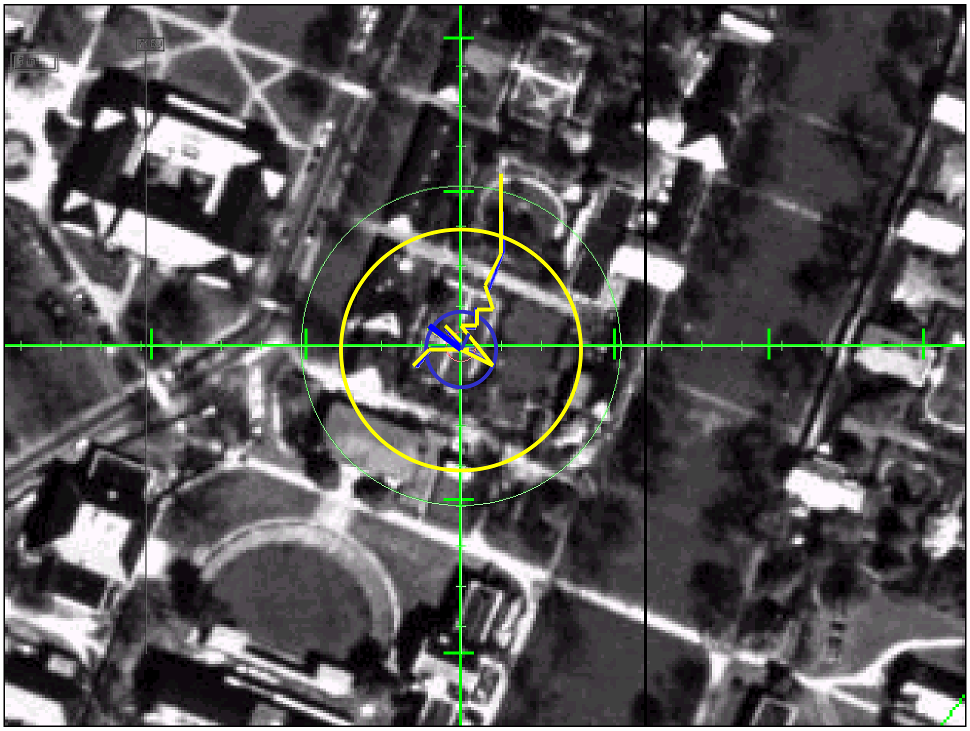
- See more satellites (15 meters)
  - Open area
  - Wait to lock on
  - Wait for better Geometry
- Obtain differential Signal (3 meter)

Improving Accuracy

- Under normal conditions the GPS unit can give coordinates accurate to 15 meters. Accuracy can often be improved by
  - Being in an open area which allows a better signal and more satellites
  - After getting the initial coordinate waiting longer for more satellites or for a differential signal
  - Waiting to lock onto satellites in a better position. Satellites closer to the horizon will often give a better position but may be more difficult to acquire.
- Waiting for a differential signal from the WAAS system will increase accuracy to 3 meters. However, since the two geosynchronous satellites are over the Atlantic and Pacific it may not always be possible to obtain the signal. The Garmin unit indicates when you have locked onto a dGPS by showing a D in the signal strength bar.

Notes:

Mapping and Theory



Summary – Accuracy Experiment

- Two Garmin Etrex GPS units where placed at the intersection to two sidewalks centered by the cross hairs with a clear view of the sky.
- The yellow circle represents 15-meter radius of expected accuracy of a unit without DGPS. The yellow line represents the positions given by the unit during one hour of recording. Notice that most of the error occurred when the unit was first turned on. After a minute accuracy was within 5 meters.
- The green circle represents 3-meter radius of expected accuracy of a unit with a DGPS signal. The green line represents the track. Once again most of the error (but still within 3 meters) occurred when the unit was first turned on.

Emphasize significant errors beyond the stated accuracy occur when the unit is first turned on. Users must wait about a minute after the initial coordinates for the required accuracy.

Notes:

Features

Features
25 minutes

SECTION THREE

Features

Section three - Features

- This section introduces the basic button, screens, and how to navigate between the screens in order to operate the GPS.
- We will also verify the proper configuration of the unit to make sure it meets FEMA standards.

Notes:

The IG covers the Garmin Etrex Vista, which was established as the standard unit for FEMA Public Assistance. During the course of instruction other units may be present. The instructor should determine which units would be present prior to instructions. Appropriate modifications to instruction should then be made.

Configurations established under FEMA Memo "*Revised GPS Equipment Specifications*"

Even is students are expected to bring their own GPS units, it is prudent to check out additional units including extra batteries.

Features

Features of eTrex Vista™

Features of eTrex Vista

- Features located on the front
  - LCD Display – Displays unit information
  - CLICK STICK – used to navigate screens, similar to a joystick, push straight in for enter
  - Antenna – built in, located under world logo. Can be degraded by hand or bar codes
- Features located on the back
  - Battery compartment – water resistant if locked properly
  - Data Connector – with supplied cable and up and download information
- Left Side
  - Power Button – flat button with I and lamp icon
  - Page Button – button on top with pages icon
- Right Side
  - Zoom button – magnify glass icon
  - Contrast button – two buttons with up and down arrows.

Notes:

Features

Installing Batteries

- Two AA last for 12 hours
- Turn-off when between work sites
- Bring extra batteries
- Battery indicator

Installing batteries

- Two double AA batteries can normally last for 12 hours; will last for about XX hours with WAAS feature turned on.
- Turn off unit when between work sites will allow batteries to last several days.
- Always carry an extra set of batteries
- A battery indicator is found on the main menu. The unit will also give a low battery-warning screen.
- To change batteries turn the D-ring a quarter turn. Remove the battery compartment cover. The unit is able to tolerate being submerged under one meter of water for 30 minutes if the case is properly replaced.

Notes:

Features

Using Button Functions

- Power Button
  - – Turning on
  - – Turning off
  - – Light
- Page
- Zoom
- Click Stick

Using button functions

- Power Button (Unit's Left Side)
  - To turn on – Press and hold power button for at least a second
  - To turn off – Press and hold power button for at least a second
  - Light- Quickly press and release power button. Light will stay lit for 15 seconds
- Page Button (Unit's Left Side) – Used to move between main screens
- CLICK STICK™ - Press in and release to enter highlighted options and confirm messages, Move up/down or right/left to move through lists, fields, icons, etc.
- Zoom in or out (Unit's right side) – use up or down arrow to zoom in or out, used with map page or with contrast settings. Adjusts contrast only when on skyplot page.

Notes:

Have class turn on unit when describing power button and instruct class not to hit any other buttons at this time.

Features

Notification Message

- After turning GPS on
- If inside – unable to find any satellites
- Error Message appears
- Acknowledge by using Click Stick™.

Notification Message

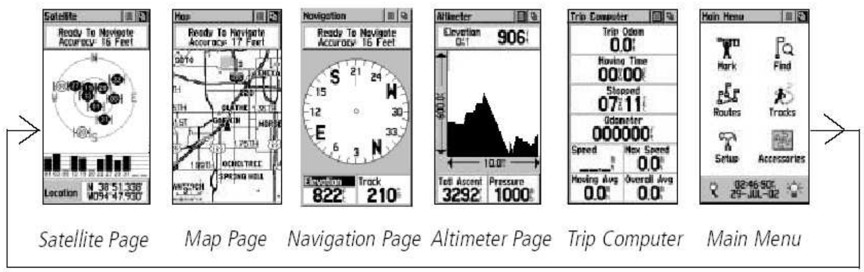
- If turning unit on inside a substantial building the GPS unit will be unable to acquire a satellite.
- Therefore, an error message will appear stating "Poor Satellite Reception" and giving four choices.
- The highlighted option represents the currently selected option.
- Use the CLICK STICK to enter "Use With GPS Off" by pressing straight down. If you want to choose another option move the CLICK STICK down.

Notes:

The instructor should check the classroom before class to determine if a satellite can be acquired. If satellites can be acquired the class can proceed as planned but actual numbers and screens can be used to describe operation. The poor satellite reception message **must** be acknowledged (by hitting enter) before other pages can be viewed.

Features

Previewing Main Pages



Previewing Main Pages

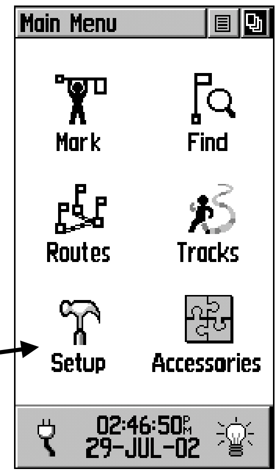
- Use the page button to view each of the main pages. The initial page will be the Satellite page. In field operations this will be only page that needs to be accessed to view coordinates. We will discuss this page in more detail later.
- Map Page – The Etrex has a built in world map. Major roads and towns of the entire US are also provided. You may zoom in and out of the map using the zoom buttons on the unit's right side.
- Navigation Page – The Vista has a built-in electronic compass. This page is also used when trying to navigate to a specific point.
- Altimeter Page – The Vista also has a built in Altimeter that measures barometric pressure.
- Trip Computer – The trip computer has a speedometer, odometer, and several other features.
- Main Menu Page – We will use this page to check the GPS unit's configuration settings. Once properly configured this page will not need to be checked again.

Emphasize the satellite page is the only page needed on a regular basis and will appear on its own. Main menu page only needed for initial configuration and checking battery status. The Altimeter should not be relied upon for flood survey work, GPS derived altitudes often have significant errors.

Features

Main Menu

- Reached by page button
- Use Click Stick to move within page
- Need to configure/check settings when issued GPS
- All configurations changes/checks from **Setup** page.



Main Menu

- Use the page button to move to the main menu.
- Six sub menus are available. We will only be using the setup menu to check configuration settings.
- Tell the class who will provide configuration on this disaster.
- Everyone needs to know how to check or reset to proper configuration.
- Use CLICK STICK to highlight setup icon and then push in.

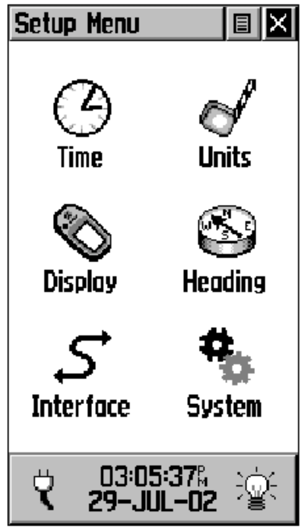
Notes:

Prior to class the instructor should determine the configuration protocol for the particular disaster. Configuration may be done by the APO on checkout, by PA on checking out, by technical services/ESF 5/GIS section, or by the user. The units are not configured by DISC and FEMA configuration is different than the default settings. A job aid is provided that also gives configuration settings.

Features

Setup Menu

- Six Options/Icons
- We will discuss
  - Units
  - System
  - Time



Setup Menu

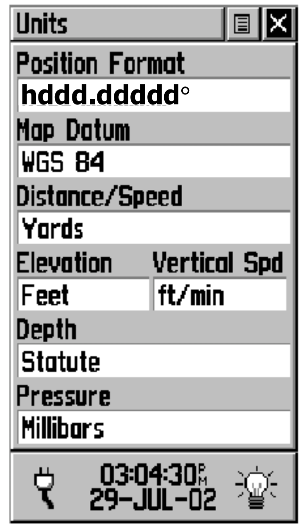
- Six icons are found on the setup menu. We will only need to discuss the units, system, and time.
- Use CLICK STICK to highlight the **Units** icon and push down to enter.

Notes:

Features

Units

- Position Format
  - hddd.ddddd
- Map Dattum
  - WGS 84 or NAD83
- Distance Speed
  - English Units



Units

Ask students, how many have the correct format of hddd.ddddd and the correct map datum?

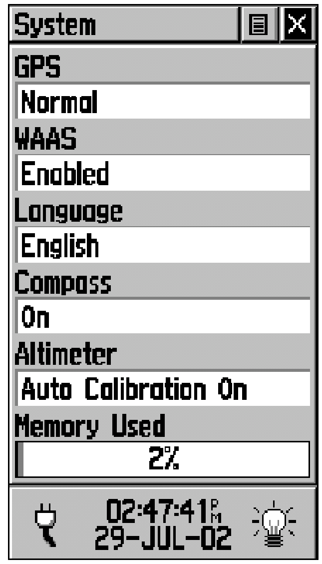
- The correct position format is decimal degrees, which is shown as hddd.ddddd. Since the default setting is decimal minutes, this might need to be changed. Use the CLICK STICK to highlight the position format box. Hit enter. Push the CLICK STICK up to scroll through the format types and locate the Decimal Degree format option. Once hddd.ddddd is highlighted hit enter to save the setting.
- The Map Datum should be set on either WGS84 (default) or NAD83. Use the same procedure outlined above to make any changes
- The Distance/Speed, elevation, depth, and pressure are not important for recording coordinates. The default settings are all correct.
- Once complete – have class show instructor settings
- After showing instructor hit page and return to setup page.

Notes:

Features

System

- GPS
  - Normal
  - Always switches to normal after being turned off.
- WAAS
  - Enabled



System

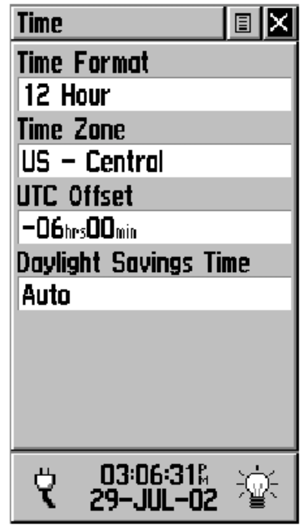
- From Setup page highlight the system icon and hit enter.
- The correct setting for GPS is “normal”. However, if unable to obtain satellites it will read “GPS Off”. This is the only configuration setting that will change after turning the unit off. It will always revert back to GPS “normal” every time the unit is turned off and on. Therefore, this setting does not need to be changed. If the unit was turned on inside and then brought outside, simply turn the unit off and on while outside.
- WAAS default position is disabled. Highlight the box and change to “enabled”.
- All other settings are not important for collecting coordinates. Although for most users “English” Language is preferred.
- Hit the page button and return to the setup menu.

Notes:

Features

Time

- Minutes and seconds are downloaded from the satellite
- Accurate as atomic clock
- Hours must be set to time zone.



Time

- Use the CLICK STICK to highlight the time icon and enter.
- Changing the time is not required for obtaining correct coordinates. It is only needed if you want the correct local time.
- The GPS unit gets Universal time from the satellites atomic clocks.
- The set the correct hour local time the GPS just needs to know the time offset from Universal time.
- Highlight the time zone box and select the appropriate time zone. The default setting is for central time.
- The UTC offset box will automatically change reflecting the offset.
- This completes the configuration process.

Notes:

Field Operations

Field Operations
25 minutes

Field Operations

- FEMA Memo "*Public Assistance Program Geocoding Guidance for the Project Worksheet (PW)*, gives guidance on where to take coordinates readings and how they should be documented in order to provide consistency throughout FEMA.
- In this section we will cover
  - Obtaining GPS coordinates
  - Where to be standing when taking coordinates
  - How to best document the coordinates

Notes:

Field Operations

GPS Safety Tips

- Turn off while driving
- Do not place on dash
- Be aware of potentially dangerous conditions
- Avoid dangerous atmospheres

GPS Safety Tips

- The GPS unit itself does not present any hazard – other than not using in dangerous atmospheres.
- The GPS unit should not be placed on the dash of your vehicle in case of an accident where it could become a missile. It should also not be placed where an airbag deployment could cause it to also become a missile.
- Its greatest threat is distracting the user from other safety hazards. It should be turned off while driving (unless you have a second person with you).
- When obtaining readings be aware of your surroundings and never place yourself in jeopardy to obtain a reading.

Notes:

Field Operations

Start-Up Location

- Travel to site
- Find a safe initial location
- Flat and level
- Open Area – Clear view of sky
- Stationary

Start up location

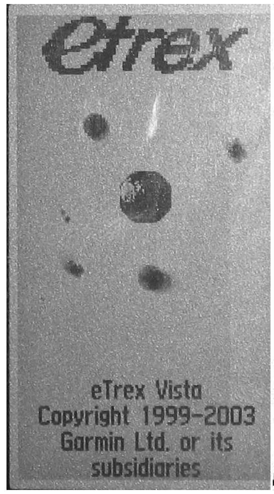
- Travel to the worksite with the GPS off.
- Upon arriving fine a safe initial location. This may often be where you have parked. The GPS unit will be able to obtain a signal through a car’s windshield in case of inclement weather.
- The GPS antenna is designed to work best when kept flat. Either on a surface or in your hand.
- The more open the area the better the reception. When using the GPS unit for the first time at a disaster, a clear view of the sky is even more important.
- During initialization it is best to keep the unit still.

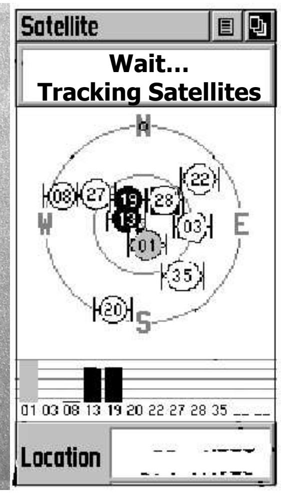
Notes:

Field Operations

Start-Up Sequence

- Press and hold power button
- Press Page button twice
- Satellite page





Start Up sequence

- Press and hold the power button for at least one second.
- The Etrex copyright page will appear. The six satellites represent the six orbital planes the actual satellites follow.
- Press the page button to move to the legal liability page. Press the page button a second time to get the satellite page.
- The message box will initially say “Wait…Tracking Satellites”. Most of the satellites in the sky plot will be white, meaning they have not been locked in. A few satellites may be gray, indicating a signal has been obtain. Satellites in black means the satellites has been acquired and locked in. Recall at least three satellites are required before a position can be fixed.

Notes:

Field Operations

Time to Acquire Reading

Start Condition	Description	Time
Hot	On within 4-6 hours	15 – 30 seconds
Warm	Within 500 miles	45 seconds
Cold	Moved over 500 miles	5 minutes*

Time to Acquire reading

- The time it takes to give you coordinates depends upon several factors.
- A hot start takes about 15-30 seconds. A hot start means the unit has already been turned on in the last 4-6 hours and all the almanac data has already been downloaded.
- A warm start is when the unit has not been turned on within 4-6 hours but it is within 500 miles of the last location is used. The additional time is required to download and update the satellite almanac, which gives the orbit information of each satellite.
- A cold start is when the unit has been moved more than 500 miles from the last location it was turned on. This can happen frequently within FEMA. Initial coordinates may require 5 minutes. The unit should be kept flat, stationary, and in an open area.

Notes:

The instructor should be familiar with the procedure to manually change the location. When poor reception message box appears, highlight and enter “New Location”, then highlight and enter “Use Map”. Use the right zoom buttons to adjust the map to the appropriate size. Use the CLICK STICK to move the cursor to the current location and then click enter.

Field Operations

Cold Starts

- Allow unit to attempt on startup (5 minutes)
- On Poor Satellite window choose new location. Then map
- Scroll triangle to location. Press ENTER
- Wait, try second location

Cold Starts

- The first time a GPS unit is turned on at a disaster will be the longest wait. Afterwards, it becomes progressively easier to use the GPS unit.
- The unit will display a Wait…Tracking Satellites when turned on. If unable to acquire satellites it will display a poor satellite reception window that gives four options. For cold starts choose the “New Location” option. Then select the “Use Map” option.
- Once the map is displayed, use the CLICK STICK to scroll to an approximation of your current location. Within 500 miles is usually sufficient. Press ENTER.
- If the unit is unable to obtain coordinates after about 5 minutes try a different location in a more open area, turn the unit off, then try again. If this fails, makes sure the batteries are fresh and try again. If this also fails, find the most open location, keep the unit still and flat, make sure nothing is blocking the antennae and allow the unit to acquire. If this fails, seek assistance. Consider the unit may be defective.

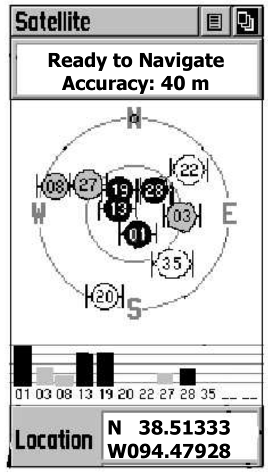
Notes:

Cold starts are the most frustrating part of using GPS units. Upon obtaining a GPS unit it best to turn it on first in an ideal location with sufficient time.

Field Operations

Satellite Page

- Status Window
- Constellation
- White, Grey, Black circles
- Signal Strength bar
- WAAS info
- Location/coordinates



Satellite Page

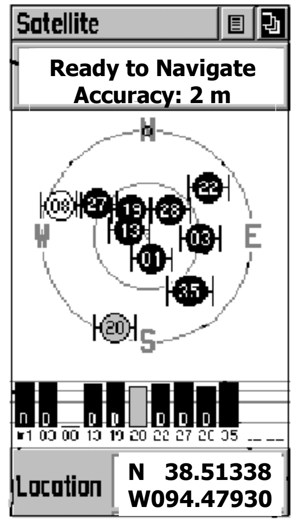
- The satellite page gives several pieces of important information
- The status window at top tells you if still acquiring satellites or once coordinates acquired the current accuracy. Note initial accuracy often poor, wait at least a minute.
- The sky plot shows the current position of all satellites above the horizon. Satellites in the center are directly overhead. The inner circle represents 45 degrees. The outer circle represents the horizon. The letters represent North, South, East and West. North is always at the top, regardless of what direction the GPS unit is facing. The initial location of the satellites is based upon the last time the unit was turned on.
- White circles indicate a signal has not been received from the satellite. Gray circle represent the satellite has been found but not locked on. Black circles represent satellites that are fully acquired.
- The signal bar gives the relative strength of the signal from each satellite. It will display a small D once it receives WAAS correction information.
- The bottom location window gives the current coordinates.

Emphasize initial accuracy poor. Waiting an additional minute or two often greatly improves the accuracy of the coordinate.

Field Operations

After initial location reading

- Accuracy improves with time
- Walk around
- Observe constellation
- Wait for better geometry



After initial location reading

- The accuracy of the coordinates improves with time. Therefore, don’t record the initial coordinates that first appear.
- Walk around to verify the coordinates are changing as you walk. The last digit represents about a meter. A small change in location may help acquire additional satellites.
- Look at the sky plot. If some satellites are still in gray, it is often worthwhile to wait until they are acquired.
- Look at the status of satellite 35 or 47. If gray or black it is worthwhile to wait until they download the dGPS information. D should start appearing in the signal strength bar.
- Look at the overall geometry. If all the currently available satellites are in close together try waiting until additional satellites become available.

Notes:

Field Operations

Where to take readings

- Safe location at site
- See satillites
- Close to center
- Front (address)
- Linear

Where to take readings

- Once several satellites are acquired you are ready to take a reading
- The first priority is choosing a location is your safety. Only take readings from safe locations.
- The second priority is a location that allows you to see satellites. For this reason you may not be able to stand in the middle or even right next to a large structure.
- The third priority is to get as close to the center of the facility as possible. It may not always be possible to achieve this.
- If unable to get to the center, move to the front of the facility on the side it has a physical address if applicable.
- For linear features take two readings. One at the start and one at the end.

Notes:

Field Operations

Emergency Work

- Category A – Debris
  - Widespread
  - Centered
- Category B – Emergency
  - Coordinates not required
  - Widespread
  - No location
  - Centered
  - Linear

Emergency Work

- Emergency work may not always lend itself to single discrete GPS coordinates.
- Debris removal operations are often widespread or even countywide, making GPS coordinates not applicable.
- However, debris management sites and staging areas need to have their locations evaluated for special considerations. Therefore, they will require coordinates.
- Coordinates are not required for category A and B – Emergency Work.

Ask the Class to give examples of when emergency work may be:

- **Widespread**
- **Have no location**
- **Centered in a discrete location**
- **Linear in nature**

Notes:

Field Operations

Example of choosing location

- Tell class they will be looking at four different facilities with damage caused by different types of events. They should look at each facility and determine where they would stand to obtain GPS coordinates. The location should be based upon
  - Safety
  - Ability to see satellites
  - Centered
  - Front
  - Linear

Solution:

- Safety: Earthquake, possible aftershocks. Avoid climbing on fallen slab, standing under standing parts of bridge. Rule of thumb, keep back 1.5 times height of structure.
- See Satellites: Should be good except for under bridge
- Centered: May use a centered approach near where bridge inspectors are standing
- Linear: Also acceptable, standing at the two approaches for the bridge on stable ground.

Notes: Show pictures, let students discuss, then give solution.

Field Operations

Example: Water Treatment Plant

- The damaged facility is a flooded pump house at a water treatment plant indicated by the circle. The pump house is currently under three feet of water. Ask the class to determine the location from which to take a GPS reading based upon safety, satellite visibility, centering, frontage, and linear.

Solution

- Safety- Wait until the floodwaters are gone, future visits are required to properly inspect the damage.
- Satellite visibility – Will be unable to obtain coordinates inside building will need to be outside.
- Centered – Centered would be inside building so will not work
- Frontage – Best location outside of building at "front" door a couple of meters away from the wall. If the building has an address (which it mostly likely lacks) take from side of building address comes from.
- Linear – Not applicable

Notes:

Field Operations

Example: Building

- The damaged facility is a public building destroyed by a tornado. Ask the class to determine the location from which to take a GPS reading based upon safety, satellite visibility, centering, frontage, and linear.

Solution

- Safety- Avoid scrambling to the top of the debris pile.
- Satellite visibility – Should be good
- Centered – Getting to the center would require climbing the debris pile.
- Frontage – Best location outside of building at former "front" door a couple of meters away from the former wall.
- Linear – Not applicable

Notes:

Field Operations

Example – damaged utilities

- The damaged facility is public utility lines and poles destroyed by a hurricane and erosion of the spit. Ask the class to determine the location from which to take a GPS reading based upon safety, satellite visibility, centering, frontage, and linear.

Solution

- Safety- Avoid getting too close to water and unstable sand.
- Satellite visibility – Should be good
- Centered – Facility is linear no single center
- Frontage – Not applicable, no address applied
- Linear – Take two readings from ends of damaged areas with safe access

Notes:

Field Operations

Preliminary Damage Assessment

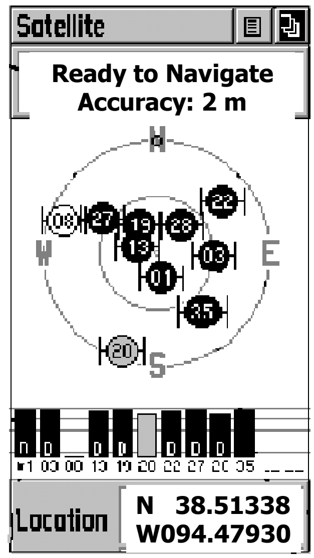
- Coordinates important at time of PDA
- Often road signs destroyed
- Critical for resource decisions

Notes:

Field Operations

Documentation

- Coordinates taken from GPS satellite page.
- Check format
  - hddd.ddddd 38.51338
- Write down as appear on unit (include N & W)
- **TAKE TIME TO WRITE CLEARLY**



Documentation

- The coordinates from the GPS unit need to be recorded onto field notes. During this step the potential for several significant errors is possible.
- The coordinates are found on the location window of the satellite page.
- Make sure the format is Decimal Degrees. If the unit is configured for another format it should be changed in the field.
- Write down the N and W that precedes the coordinates.

Notes:

If the class is being taught in Alaska or the Pacific Islands, it should be pointed out that the GPS might indicate E longitude.

Field Operations

GPS to Field Notes Errors

- Writing down wrong coordinates
- Check coordinates after recording
- One person read coordinates, second person verify
- Write neatly
- Clearly record site

GPS to Field Notes Errors

- The most common errors when recording coordinates to field notes include transposing digits, reversing North and West, and the inability to read handwriting later.
- Take time to clearly print the coordinates. If in inclement weather using a pencil versus an ink pen, this prevents ink from running if the paper gets wet.
- If you have a second person with you, you may want the second person to read back the coordinates or verify what you have written. If alone, be sure to verify coordinates against the GPS device after they are written down. However, keep in mind the last digit may have changed due to inaccuracy of the GPS unit.

Notes:

Field Operations

Field Notes to PW

- Be Careful
- Check data entry
- N latitude entered as positive number
- W longitude entered as a negative number
  - All CONUS W (-)
  - Locations west of international dateline entered as E (+)

Field Notes to PW

- The transfer of coordinates from field notes to the Project Worksheet (PW) template (often a Word or Excel file) represents a second opportunity for transfer errors.
- Enter numbers carefully. Be sure to enter North latitudes as a positive value and W longitude as a negative value.
  - All locations in CONUS (continental United States) will be N latitude and W longitude.
  - Locations west of the international dateline (parts of the Alaskan Aleutian islands, and pacific territories)

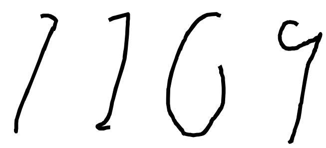
Notes:

The initial illustration shows the correct coordinates and location of Emmitsburg, MD. The second click shows the location if the negative number is not correctly entered, placing the location in China.

Field Operations

Field Notes to PW

- Some digits easily confused
- 9 and 4
- 1 and 7
- 0 and 6
- 2 and 7



Field Notes to PW

- Handwritten Project Worksheets still account for 10% of the PWs submitted to NEMIS data entry.
- In reading other people's handwriting certain digits are commonly misinterpreted, as noted on the slide.
- Use care with all digits.

Ask the class: What is the number?

Notes:

The correct number is 7209, which will be displayed on the second click on the mouse.

Field Operations

Coordinates for Single Site

FEDERAL EMERGENCY MANAGEMENT AGENCY **PROJECT WORKSHEET**				O.M.B. No. 3067-0151 Expires April 30, 2001

PAPERWORK BURDEN DISCLOSURE NOTICE

Public reporting burden for this form is estimated to average 30 minutes. The burden estimate includes the time for reviewing instructions, searching existing data sources, gathering and maintaining the needed data, and completing and submitting the form You are not required to respond to this collection of information unless a valid OMB control number is displayed in the upper right corner of the forms. Send comments regarding the accuracy of the burden estimate and any suggestions for reducing the burden Information Collection Management, Federal Emergency Management Agency, 500 C Street, SW, Washington, DC 20472, Paperwork Reduction Project (3067-0151). **NOTE**: Do not send your completed form to this address.

DECLARATION NO: **FEMA-** **-DR-**	PROJECT NO.	FIPS NO.	DATE	CATEGORY
DAMAGE FACILITY			WORK COMPLETE AS OF: : %	
APPLICANT		COUNTY		
LOCATION			LATITUDE	LONGITUDE

If linear feature, second coordinates entered into comments

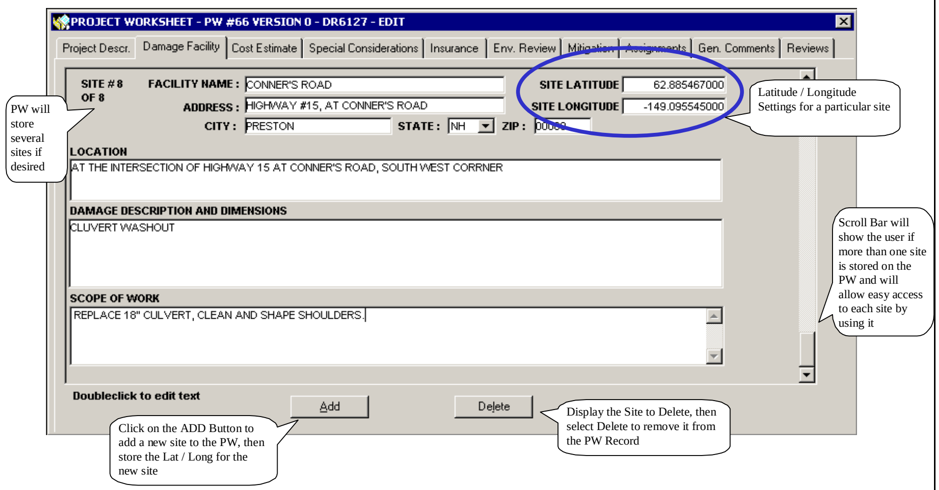
Coordinates for Single Site

- For a single site, coordinates are entered into the face sheet of the Project Worksheet.
- If the site is linear, the start coordinates are entered into the face sheet of the Project Worksheet; the second coordinates are entered in the comment section of NEMIS.
- Multiple sites are covered on the next slide.

Notes:

Field Operations

Coordinates for Multiple Sites



Coordinates for Multiple Sites

- If entering multiple sites on one PW, the NEMIS screen allows entering coordinates for each site.
- For linear damaged facilities, the second coordinate should be entered into the comments section.

Notes:

Field Operations

Data Entry into NEMIS

- If electronic copy of PW available, copy and paste coordinates into NEMIS
- Often need to add (-) sign to longitude if in CONUS
- Check for correct format hdd.ddddd, make sure not in hdd mm.mmmm
- Use job aid to verify coordinate in correct state.
- Typed versions of PW significantly reduces error.

Data Entry into NEMIS

- The final potential for errors is data entry of coordinates from a PW into NEMIS by data entry personnel.
- If an electronic PW is available, the coordinates should be copied and pasted directly into NEMIS. This is possible with both Word or Excel documents.
- Data entry should verify the correct decimal degree (hddd.ddddd) format has been used. If the format is degree decimal minutes (hdd mm.mmmm) use the job aid to convert to decimal degrees.
- Data entry should also use the job aid to verify the coordinates fall at least into the correct state.

Notes:

The excel job aid may be downloaded from:

www.training.fema.gov/emiweb/dfto/GPS.asp

The instructor may also pass out floppy disks with the excel job aid.

Practical Exercise

Unit Five

Practical Exercise

Practical Exercise

Notes:

Prior to Class

- Select a location where it is possible to acquire satellites, large enough for the entire class, within easy proximity to the classroom, and safe for the students.
- Some coordination with safety and security may be required prior to the class.
- Also select a spot that allows for a plausible Public Assistance scenario. Possible scenarios include damaged buildings, sidewalks, roads, parking lots, culverts, or utilities.

While in the Classroom

- Passout GPS Practical Exercise handout
- Review instructions in handout
- Remind class to reassemble in classroom after exercise at specified time.

During Practical Exercise

- Point out scenario location, for the second scenario consider a discrete spot that can be compared in the classroom.
- Assist students

GPS Practical Exercise	1. Name	2. Location	3. Date/Time

Section A - Initialization

Instructions: Please record the requested information. If the block is grayed-out it is not required to fill in the box. 4. Turn on the GPS outside (if already on, turn off and then back on), and go to the satellite page by pressing the page button twice. Record the total number of satellites the unit has initially acquired. 5. The moment the GPS unit gives coordinates, record the initial accuracy, then record the total number of satellites.
6. One minute after recording the initial accuracy record the new accuracy and number of satellites.
7. Two minutes later once again record the accuracy and number of satellites. 8. Wait for a differential signal indicated by the letter D in the signal bar (satellite #35 or #47), wait an additional two minutes then record the accuracy and number of satellites. If after a total of 5 minutes unable to get a dGPS signal, skip to section B.

EVENT	Time	Accuracy	# of Satellites
4. Turn On Unit			
5. Initial Coordinates			
6. One minutes after Initial Coordinates			
7. Two minutes later			
8. Two minutes after Differential Signal			

Section B - Interference

Instructions: Section B allows the user to experiment with various factors that may block or weaken the GPS signal. The GPS unit must be on the satellite page for all activities in order to view the accuracy. 9. Record the accuracy and number of satellites while standing in the open. This may be the same reading recorded in line seven. 10. Place your hand over the antennae (located under the globe logo) for 30 seconds and record the accuracy and number of satellites. After recording the information allow at least a minute to allow the GPS unit to normalize before proceeding to the next measure. 11. Hold the GPS unit in a vertical position then record the accuracy and number of satellites. 12. Walk next to a substantial building then record the accuracy and number of satellites. 13. Walk under a tree (if available), then record the accuracy and number of satellites.

EVENT	Accuracy	# of Satellites
9. Under Open Sky		
10. Hand over antennae		
11. Hold GPS unit upright		
12. Reading close to building		
13. Reading under a tree		

Section C - Unit Comparison

Instructions: Find a partner to make teams of two. Move to an open safe location and place the two GPS units side by side. Record the coordinates from both units.

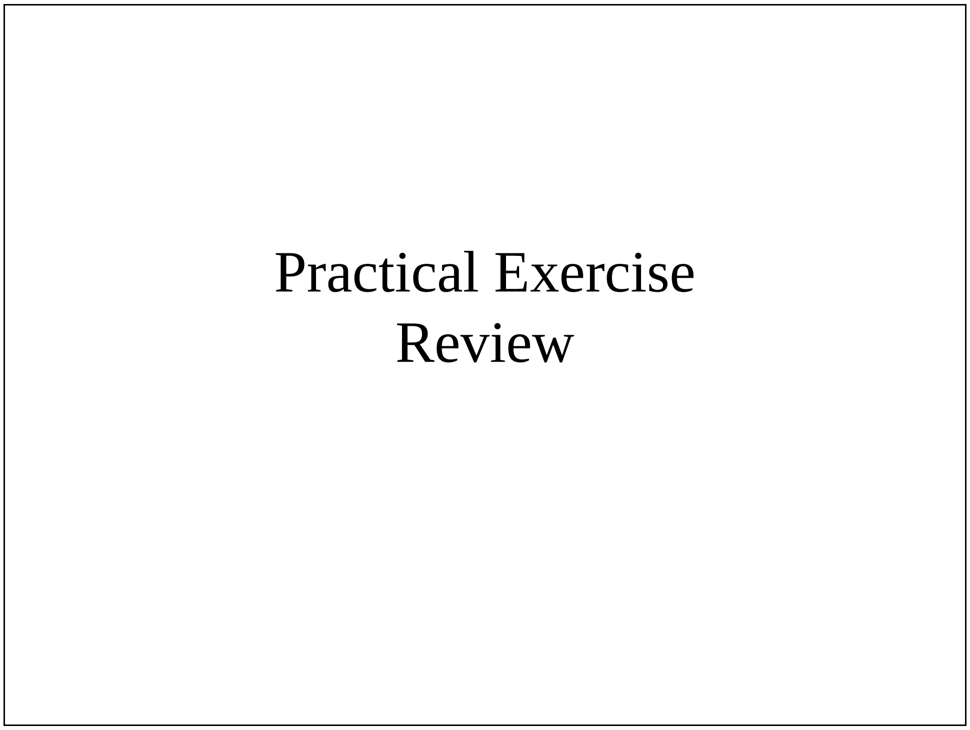
	Latitude	Longitude
Your Coordinate	N	W
Partner's Coordinate	N	W

Section D - Scenario's

Instructions: Your instructor will give you one or two scenarios of damaged facilities. Determine the best location to take a GPS reading from and record your coordinates.

	Latitude	Longitude
Scenario 1	N	W
Scenario 2	N	W

Practical Exercise



Practical Exercise Review

- Upon returning to the classroom, review the results of the exercise.
- Place on the board the coordinates of the scenarios. If any students had significantly different answers, check their configurations.

Notes:

Quality Control

Unit Six

Quality Control

Introduce Unit Six – quality control

- After coordinates have been obtained and entered into a PW template, the project officer should verify the coordinates.
- This quality control step will catch most of the significant sources of error.
- Quality control consists of entering the coordinates into a mapping program and seeing if the plotted location matches the damaged facility.
- Both basic web-based and software based mapping programs will be discussed.

Notes:

If time and logistics permit, the web-based software can be demonstrated if an Internet connection exists. The instructor should use the coordinates recorded from the practical exercise. The software based programs if available from the DFO should be loaded onto the presentation machine. Otherwise, the screen shots provided in the PowerPoint presentation may be used.

Quality Control

Quality Control

- Are your coordinates correct?
- Several different methods to check.
- Compare to original field notes
- Check against acceptable ranges Job Aid
- Enter coordinates into mapping program
- Users (Data entry, GIS, Mitigation, Environmental, Historic) bring quality problems to PO or PAC

Quality Control

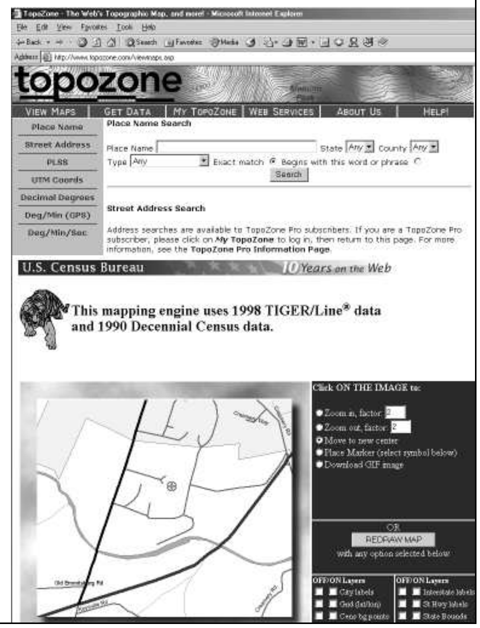
- Since coordinates are simply strings of numbers it is difficult to quickly verify that the numbers you entered into the PW are the correct coordinates.
- We will discuss several different methods to verify the coordinates.
- The simplest is to compare the PW against the original field notes.
- A job aid has also been prepared that gives the acceptable ranges for each state and county. The coordinates should be checked against these ranges.
- A better quality check is to enter the coordinates into a basic mapping program to verify the location.
- Users of the coordinates may also bring quality problems to the attention of the PO or PAC once they attempt to use them in the field. However, this is the least desirable method of quality control.

Notes:

Quality Control

Web-based Mapping Services

- Topozone
  - City name & coordinates
  - **www.topozone.com**
- US Census Tiger Map
  - City name & coordinates
  - Tiger.census.gov
- MapQuest
  - Address only
  - www.mapquest.com



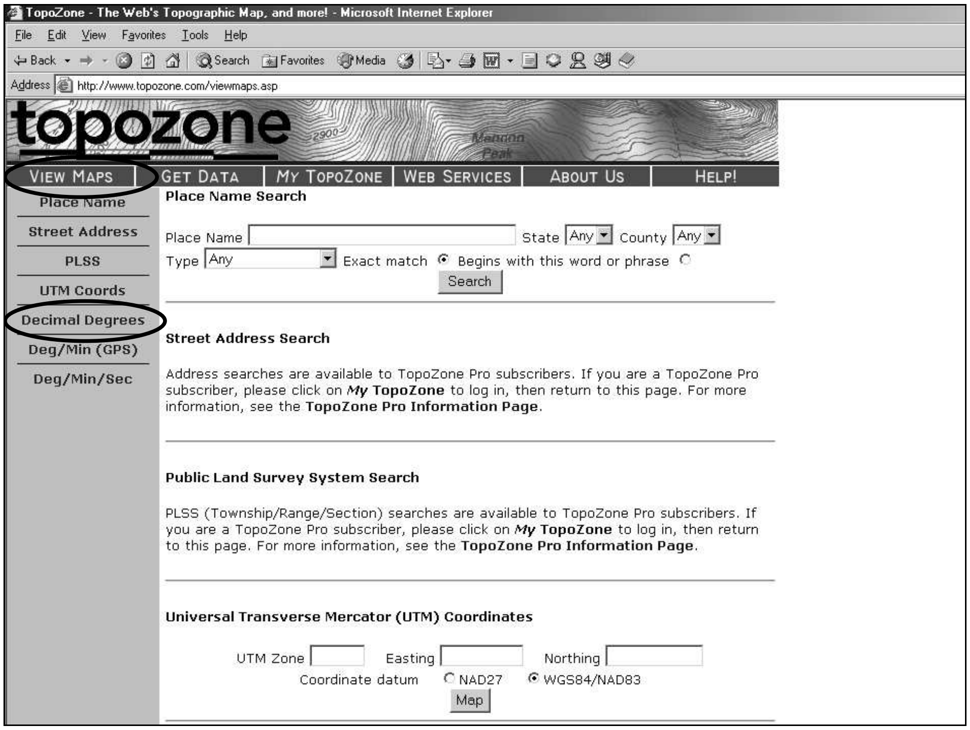
Web-based mapping programs

- The three web-based mapping services are Topozone, Census Tiger Server, and MapQuest. Each has different strengths and weaknesses.
- Topozone can use coordinates or an address to mark a specific location on a topographic map. This is perhaps the best service for zooming into a specific location for verifying coordinates. The steps will be shown in a series of screen shots shortly.
- US Census Tiger Server uses coordinates to mark a specific location on a road map. This is also a good service for location verification if the user does not like topographic maps.
- MapQuest is well known for finding an address and getting directions. However, it does not use geographic coordinates.

Notes:

The next five pages are screen shots from Topozone and Tiger Server. If an Internet connection is available the actual programs may be used.

Quality Control

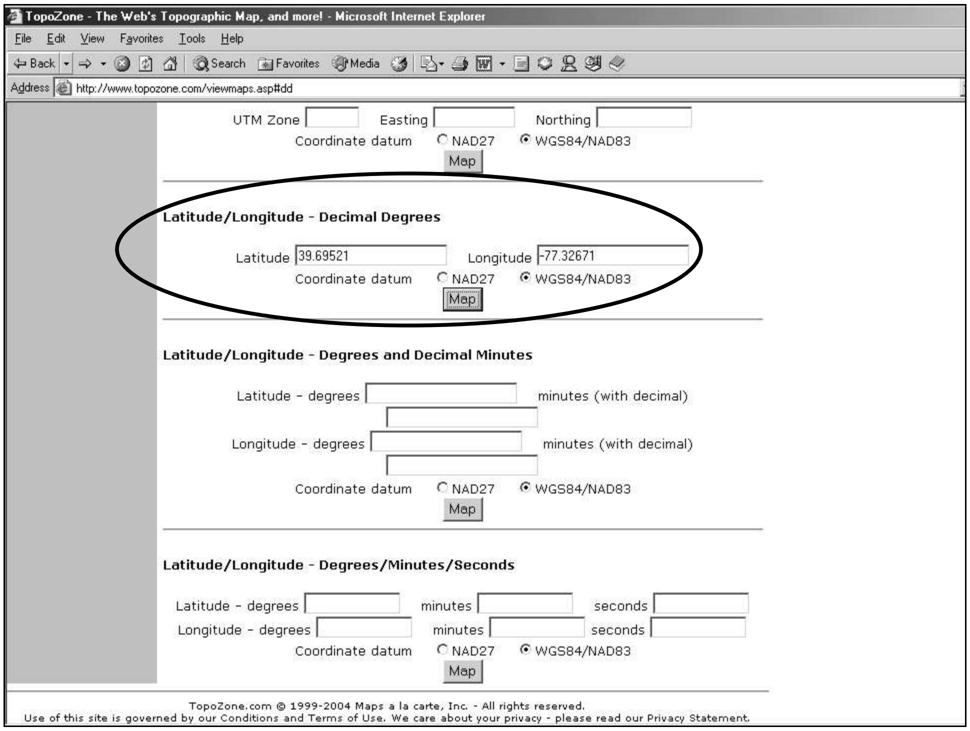


Using Topozone

- Open Topozone at www.topozone.com.
- Click on View Maps in upper left corner, and then click on Decimal Degrees.

Notes:

Quality Control

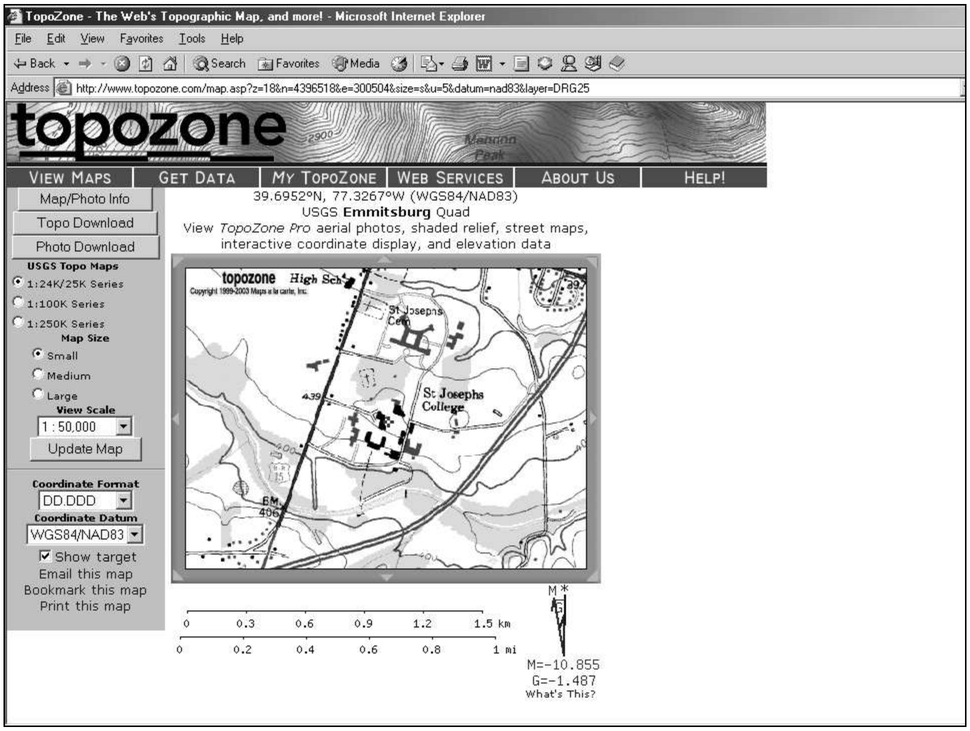


Using Topozone

- Enter the decimal degrees into the correct boxes. Be sure Longitude is entered as a negative number.
- Select WGS84/NAD83 as your map datum
- Hit enter or click on the Map button

Notes:

Quality Control

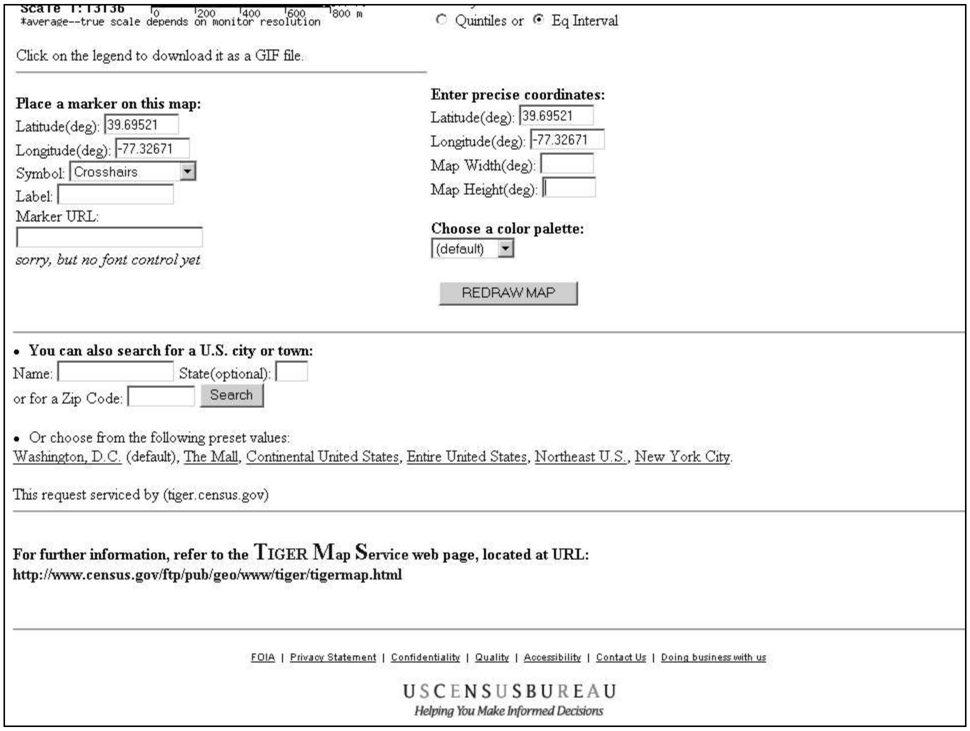


Using Topozone

- The program will then show you a topographic map with your coordinate marked by a red cross. This will allow you to verify your coordinate. The topographic map is useful for locations both on and off road. However, many topographic maps are several years old and may not show new development. The above example still lists EMI as St. Josephs College.
- The map will already be zoomed in as much as possible.
- To zoom out, switch the View Scale to a larger number.

Notes:

Quality Control

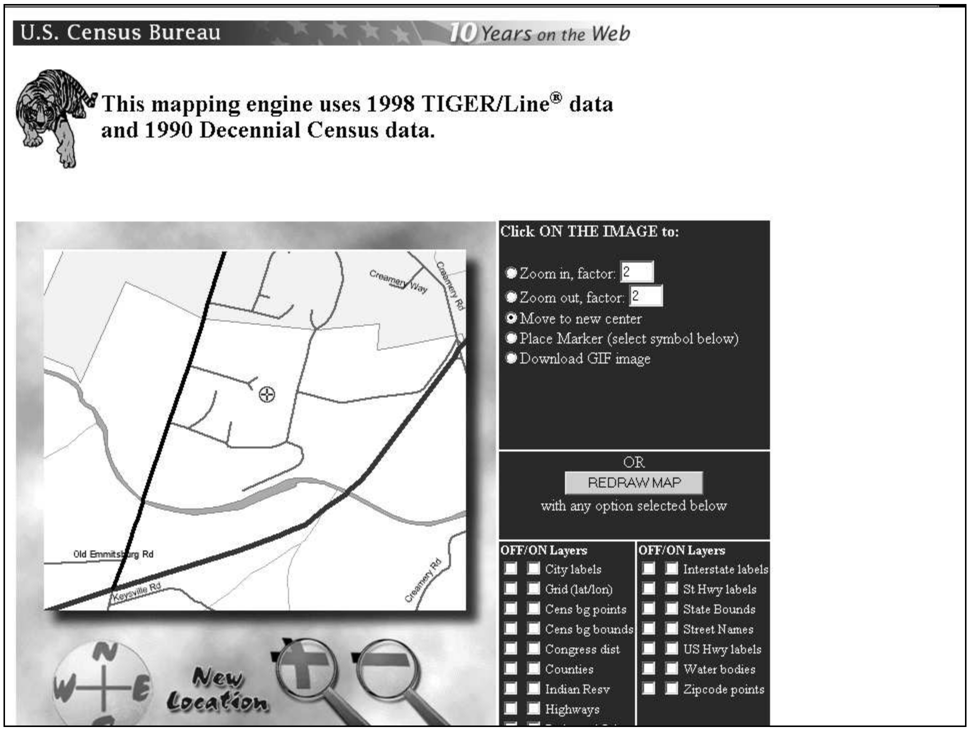


Tiger Census Map

- The US Census has a similar web-based map service that instead of displaying a topographic map shows road maps.
- In your browser enter the URL of tiger.census.gov then On-Line Mapping and then TIGER Map Server. Alternatively, enter the URL tiger.census.gov/cgi-bin/mapbrowser-tbl to go directly to the correct page.
- Scroll down the page to the Enter precise coordinates: and place a marker on this map boxes.
- Enter the coordinates in both locations. Be sure to make the longitude negative is using West longitude. Hit “Redraw Map”

Notes:

Quality Control



Basic Mapping Programs

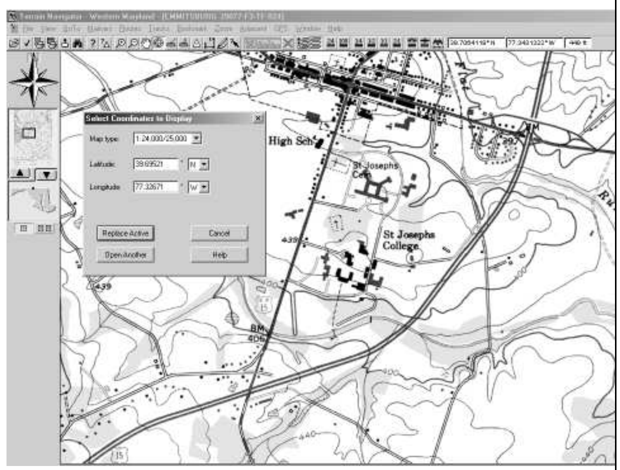
- A road map is displayed with the coordinates indicated by a marker.
- Click on the magnify glass to zoom in or out.
- If the damaged facility is near a road then its location can be verified.

Notes:

Quality Control

Basic Mapping Programs

- Microsoft Streets & Trips
- Maptech Terrain Navigator

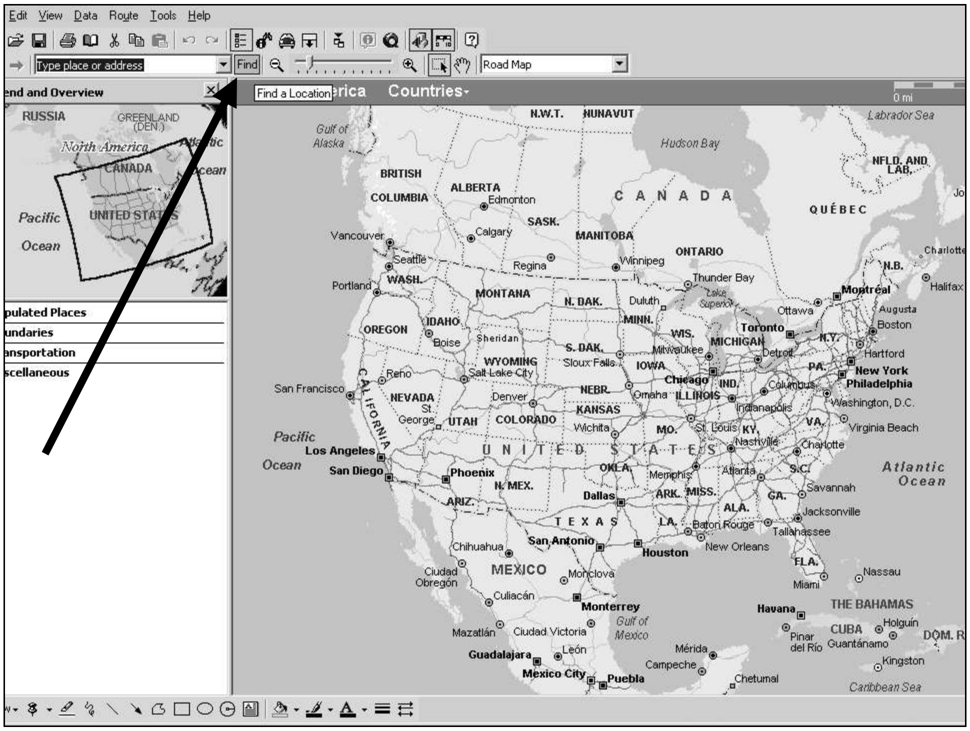


Basic Mapping Programs

- In addition to the Internet, several computer based mapping programs exist.
- For this class we will quickly show two basic programs that could be used to verify coordinates. Keep in mind that GIS/Technical Services will have advanced programs with several different features, in addition to technical expertise for advanced issues.
- The two basic programs we will mention are Maptech Terrain Navigator and Microsoft Streets and Trips. Availability will vary depending upon the disaster and region.
- Shown in the slide is a screen shot from Terrain Navigator. By selecting "GoTo" from the toolbar and then "coordinates" you open the "Select Coordinates to Display" Window. Enter the Decimal Degree coordinates. Instead of using a negative sign with the longitude make sure to use West or East.
- After hitting enter a topographic map will be displayed with your coordinate in the center. In addition, as you move the cursor over the map the cursor's coordinates will be displayed.

Notes:

Quality Control

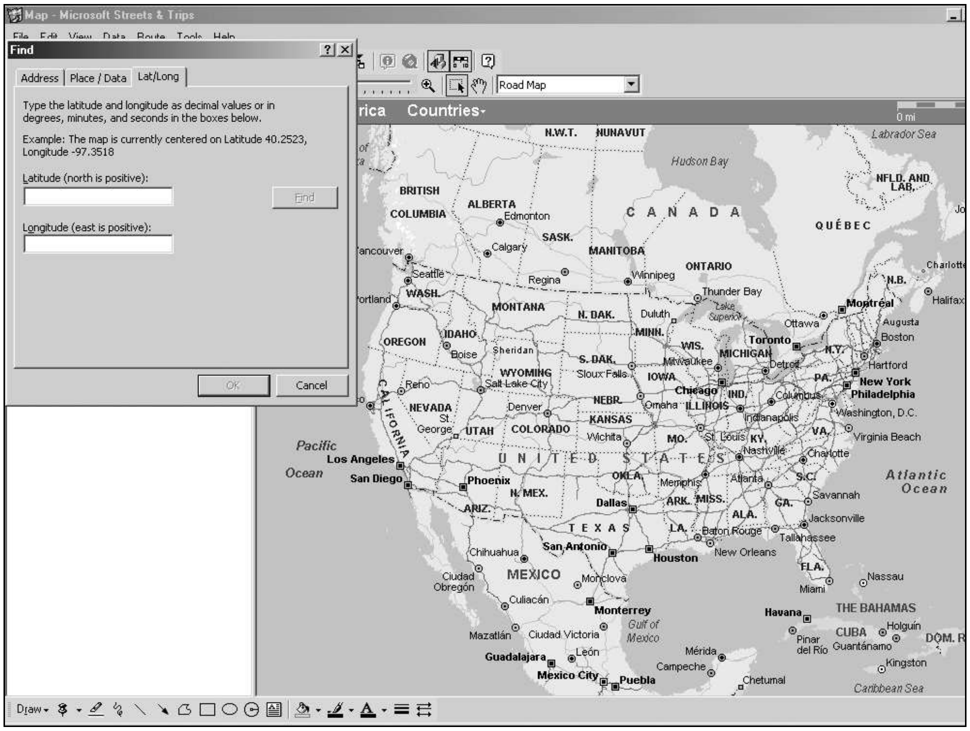


Using MS Streets & Trips - Find

- Shown is a screen shot from Microsoft Streets and Trips. To verify a coordinate click on the find button.

Notes:

Quality Control

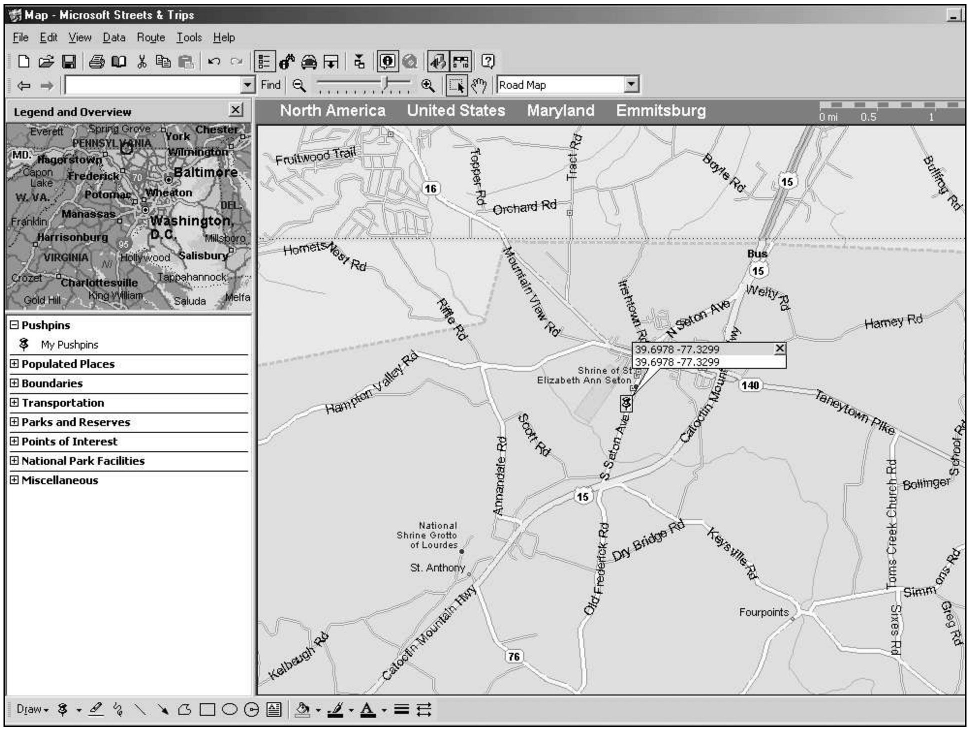


Using MS Streets & Trips – Geographic Find box

- That will open the find window.
- Click on the Lat/Long tab.
- Enter the decimal degree Latitude and Longitude.
- Remember to make the Longitude negative if in CONUS or using W Longitude.
- Click on "OK."

Notes:

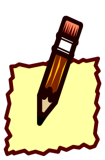
Quality Control



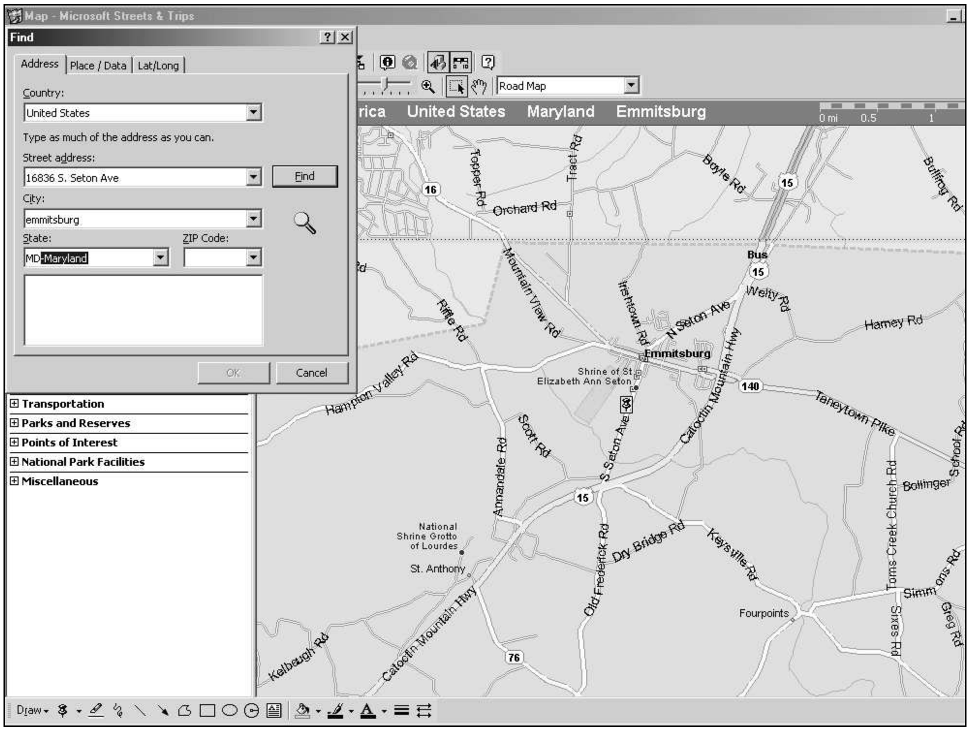
Using MS Streets and Trips – Gives Location

- The program maps out the GPS coordinate with a Push Pin, plotted onto a road map.
- Road map is made using census data, so in more rural locations it may be slightly shifted from actual location. In urban areas maps have been corrected.

Notes:



Quality Control



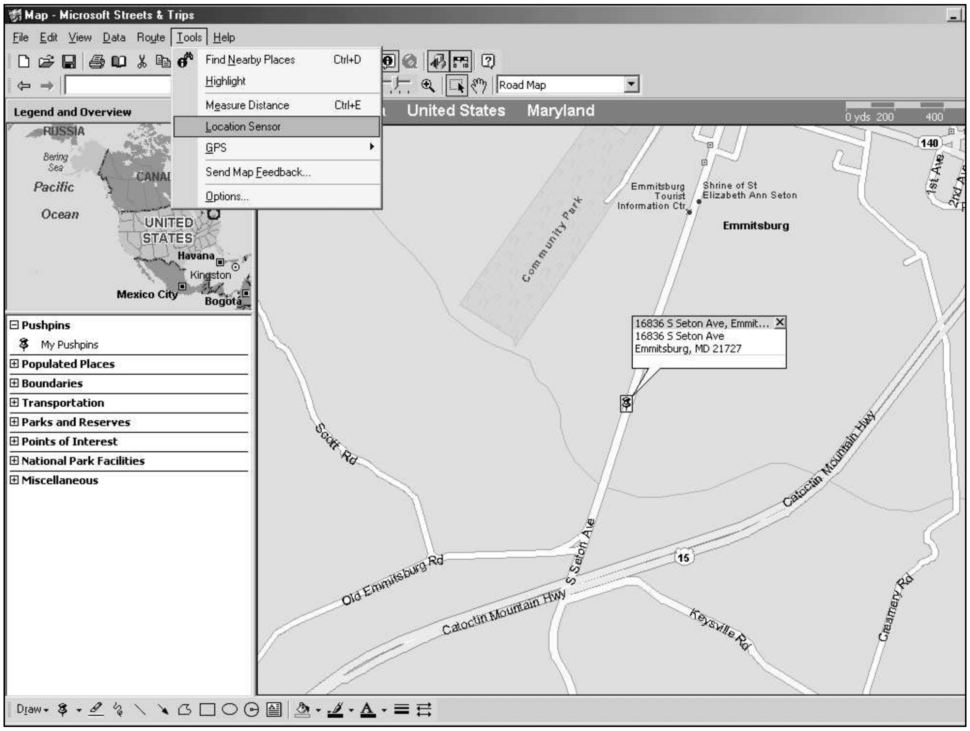
Using MS Streets and Trips – Address Find box

- If unable to obtain GPS coordinates because of poor satellite reception it is possible to use the software to obtain coordinates if a physical address is known.
- This method is not a shortcut to actually taking a GPS reading, since several mapping errors exist in Microsoft Streets and Trips.
- Click the Find button to once again open the Find window. Enter the address and click "OK".

Emphasize, actual GPS coordinates must be taken whenever possible. Using Microsoft Street and Trips to determine coordinates will result in errors in many locations.

Notes:

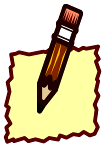
Quality Control



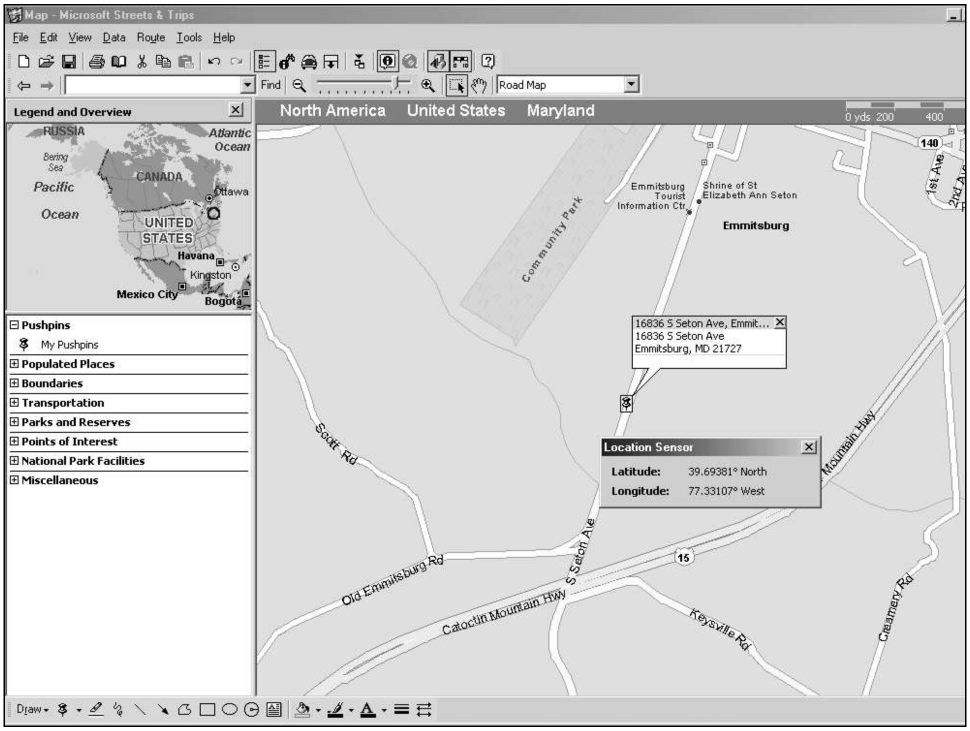
Using MS Streets & Trips – Opening Location Sensor

- The map will place a pushpin at the specified address.
- To determine the GPS coordinate
  - Click on tools from the toolbar
  - Then choose the Location Sensor
  - Hit enter

Notes:



Quality Control



Using MS Streets and Trips – Mouse cursor gives latitude and longitude

- The Location Sensor window will open.
- The decimal degree coordinates of the cursor are indicated in the box to a precision of one meter.
- Move the cursor to the pushpin or other desired location to read the coordinates.

Notes:

Instructor must stress that obtaining GPS from software should never replace using a GPS unit to obtain actual readings.

Summary

Summary
5 minutes

Section Seven

Summary

Introduce Summary section

- A GPS unit is a scientific instrument that must be properly configured but once set up is relatively easy to use.

Notes:

Summary

Objectives

- ✓ Explain FEMA's use of coordinates.
- ✓ Explain basic GPS theory as applied to actual field use.
- ✓ List common problems and their prevention.
- ✓ Demonstrate the ability to configure the unit, obtain, record, and verify coordinates in the field.

Summary of Objectives

- Review objectives.

Notes:

Summary

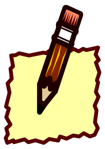
Summary Source of Error

Type of Error	Source of Error	Effect
dGPS	GPS system	3 m
GPS	GPS system	15 m
Wrong Datum	Configuration	0.1 km
Wrong Format	Configuration	50 km
Transposing Digits	Human	5,000 km
Wrong Sign	Human	Half the world

Sources of Error

- FEMA tolerance for coordinates is 20 meters.
- A properly configured GPS is capable of being accurate to 3 meters when it receives a differential WAAS signal, or accurate to 15 meters without the extra signal.
- If the wrong datum as been configured the error will range between 5 – 100 meters. In Alaska the error can be 200-400 meters.
- If the wrong format as been configured the error may be as much as 50 km.
- By accidentally transposing digits it is possible to create an error of 5000 km.
- Entering the wrong sign for longitude will create an error exactly half the world away.

Notes:



Summary

Summary Field Operation

- Good safe location
- Turn on unit
- Wait for good satellite signal
- Walk to proper location
- Record coordinates
- Quality check data upon return

Summary of Field Operations

- GPS units are designed to be as easy to use as possible. The procedure to obtaining a good coordinate once the unit has been properly configured is quite straightforward.
- Travel to a safe location.
- Turn the unit on.
- Wait for a good satellite signal.
- Walk to the location where you need to obtain coordinates.
- Record the coordinates.
- Quality-check your coordinates upon return to the office.
- Enter your coordinates into the project worksheet.

Notes:

Summary

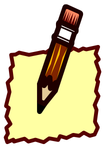
Additional Resources

- User's manual – www.garmin.com/
- Tutorial on GPS
  - – Trimble site www.trimble.com
  - – Garmin book www.garmin.com
- WAAS Information FAA site gps.faa.gov
- USGS Mapping and Datums www.usgs.gov
- USCG GPS Site www.navcen.uscg.gov

Additional Resources

- This course was designed to only touch upon the essentials required to obtain good coordinates with a civilian GPS unit. The unit is capable of several additional functions. To learn more about the features of the GPS unit refer to your user's manual, which should have been included in the box with the GPS. If not included, it may be obtain on-line directly from Garmin at www.garmin.com.
- Two sites give a more detailed tutorial on how the GPS works.
- The FAA has a site that gives additional information on the current system with several links.
- For more information on mapping and Datums visit the US Geological Survey page.
- The US Coast Guard also maintains a web page that gives a daily map of what areas of the US will have good or bad satellite geometry.

Notes:



Summary

Questions?

Questions

- Ask students if any questions remain.

Notes: